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Aerodynamic Influence Coefficients  
from Piston Theory:  
Analytical Development  
and Computational Procedure

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15 AUGUST 1962

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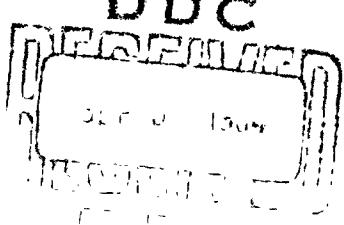
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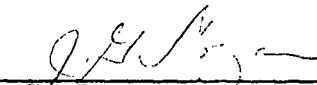
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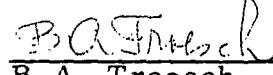
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PISTON THEORY: ANALYTICAL DEVELOPMENT  
AND COMPUTATIONAL PROCEDURE

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## ABSTRACT

In this report we present a method for calculating the aerodynamic influence coefficients (AICs) based on third-order piston theory with an optional correction to agree with Van Dyke's quasi-steady second-order theory. The AICs are computed assuming the airfoil to have a rigid chord with or without a (rigid chord) control surface. The influence coefficients relate the surface deflections to the aerodynamic forces through the following definitions. In the oscillatory case,

$$\{F\} = \rho \omega^2 b_r^2 s [C_h] \{h\}$$

and in the steady case,

$$\{F_s\} = (1/2) \rho V^2 (S/c) [C_{hs}] \{h\}$$

The piston theory is limited to high Mach number (or high reduced frequency), but Van Dyke's quasi-steady correction extends the validity to some lower supersonic Mach number at low reduced frequency.

The Aerospace IBM 7090 Computer Program Number HM11 provides the AICs from this theory in both a printed and an optional punched-card output format. The program capacity is 25 surface strips, 15 Mach numbers, and 20 reduced velocities for each Mach number.

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## SYMBOLS

$a_o$	Ambient speed of sound
$b$	Local semichord
$b_r$	Reference semichord
$C_h$	Element of oscillatory aerodynamic influence coefficient matrix
$C_{hs}$	Element of steady aerodynamic influence coefficient matrix
$C_n$	Coefficients in expressions for pressure coefficient
$C_p$	Pressure coefficient
$c$	Local chord
$c_a$	Control surface chord
$\bar{c}$	Mean aerodynamic chord
$d$	Distance between forward and aft control points
$F$	Control point force
$g$	Airfoil semithickness
$g_x$	Slope of airfoil, $g_x = dg/dx$
$h$	Vertical deflection
$I_n, J_n$	Thickness integrals
$K_n$	Coefficients in expressions for oscillatory aerodynamic coefficients
$k$	Local reduced frequency, $k = \omega b/V$
$k_r$	Reference reduced frequency
$L_{h_o}, L_{a_o}, L_{\beta_o}$	Oscillatory leading edge lift coefficients

$L_o$	Lift referred to leading edge motion
$M$	Free stream Mach number
$M_{h_o}, M_{a_o}, M_{\beta_o}$	Oscillatory leading edge pitching moment coefficients
$M_o$	Pitching moment about leading edge referred to leading edge motion
$p$	Surface pressure; $p_o$ is ambient pressure
$q$	Free stream dynamic pressure
$r_h, r_t$	Ratios of hinge-line and trailing-edge thicknesses to maximum thickness, respectively
$S$	Wing area
$s$	Wing semispan
$T_{h_o}, T_{a_o}, T_{\beta_o}$	Oscillatory leading edge hinge moment coefficients
$T_o$	Hinge moment referred to leading edge motion
$t_{max}$	Airfoil maximum thickness
$V$	Free stream velocity
$V/b_r \omega$	Reference reduced velocity, $V/b_r \omega = 1/k_r$
$v$	Unsteady component of downwash velocity
$w$	Downwash velocity
$x$	Chordwise coordinate; $x_o$ is coordinate of pitching axis; $x_m$ is coordinate of maximum thickness point; $x_h$ is coordinate of hinge line
$\alpha$	Angle of attack; $\alpha_o$ is initial angle of attack
$\beta$	Control surface incidence; also, $\beta = (M^2 - 1)^{1/2}$
$\gamma$	Specific heat ratio of air, $\gamma = 1.400$
$\Delta y$	Strip width

$\Lambda$	Leading edge sweep angle
$\xi$	Dimensionless chordwise coordinate, $\xi = x/c$
$\rho$	Free stream density
$\tau, \tau_h, \tau_t$	Airfoil thickness ratios at point of maximum thickness, hinge line, and trailing edge, respectively
$\omega$	Circular frequency
$(\bar{\cdot})$	Bar denotes term depends on flow characteristics normal to leading edge
[ ]	Square matrix
{ }	Column matrix

## SECTION I

### FORMULATION OF THE PROBLEM

#### A. Introduction

The pressure on a lifting surface is normally given by a surface functional relationship. However, in the limit of a high Mach number (or high reduced frequency), this relationship becomes a point function. As a consequence of this limit, aerodynamic influence coefficients (AICs) may be specified exactly by a strip theory, and control surface and camber effects may be determined in a straightforward manner.

The present formulation derives the AICs from third-order piston theory for a lifting surface with control surface (both assumed rigid in the chordwise direction; i. e., no camber is presently considered). The derivation differs only slightly from that of Ashley and Zartarian<sup>1</sup> in that in the present case the third-order pressure coefficient is generalized to account for sweep and steady angle of attack, and, following a suggestion of Morgan, Huckel, and Runyan,<sup>2</sup> a correction (optional) is suggested to give agreement with the second-order quasi-steady supersonic theory of Van Dyke.<sup>3</sup> This quasi-steady correction should extend the validity of the piston theory to lower supersonic Mach numbers at low reduced frequencies. The derivation given here is taken from Ref. 4; further, the computational aspects of the present report are an extension of the computing procedure of Ref. 4.

#### B. Sign Convention

The flutter sign convention is used in the oscillatory case: forces and deflections are positive down; rotations are positive with leading edge up. The aerodynamic sign convention is used in the steady case: forces and deflections are positive up; rotations are positive with leading edge up.

### C. Derivation of Equations

We quote here the development of Miles<sup>5</sup> in obtaining the piston theory pressure coefficient. There are two cases of interest. The first assumes that the angle of attack is small enough that there are pressure perturbations on the expansion side of the surface. The second assumes that the angle of attack is large, and that the expansion pressure approaches a vacuum and is ineffective in producing perturbations. Because of the difficulty in specifying the transition from low to high angle of attack, we shall restrict the present consideration to the first case, the low angle of attack.

"Hayes' hypersonic approximation states that any plane slab of fluid initially perpendicular to the undisturbed flow may be assumed to remain so as it is swept downstream and to move in its own plane under the laws of one-dimensional, unsteady motion. Thus, the problem of a wing having an arbitrarily prescribed motion normal to its surface may be reduced to the consideration of the one-dimensional motion of a piston into an otherwise undisturbed flow. This problem is relatively simple if the disturbances produced by the piston are treated as simple waves, for then the pressure on the piston depends only on the instantaneous velocity there,  $w$ , and is given by

$$\frac{p}{p_0} = [1 + (1/2)(\gamma - 1)(w/a_0)]^{2\gamma/(\gamma - 1)} \quad (1)$$

where  $p_0$  and  $a_0$  are the values of pressure and sonic velocity in the undisturbed flow.

"The result, Eq. (1), is exact for an expansion, but the presence of a shock front (and consequent departure from isentropic flow) renders it only approximate for a compression. Lighthill has suggested a cubic approximation

to be adequate for practical application if  $|w/a_o| < 1$ . The series expansion yields

$$\begin{aligned} p/p_o = 1 + \gamma(w/a_o) + (1/4) \gamma(\gamma + 1) (w/a_o)^2 \\ + (1/12) \gamma(\gamma + 1) (w/a_o)^3 . \end{aligned} \quad (2)$$

Lighthill has shown that this expression, Eq. (2), is within six percent of the value given by either Eq. (1) or the exact solution with the shock at maximum permissible strength.<sup>5</sup>

The pressure coefficient  $C_p = (p - p_o)/q$  is found from Eq. (2) after noting that  $q = (\gamma/2) p_o M^2$ .

$$\begin{aligned} C_p = (2/M^2) [ (w/a_o) + (1/4) (\gamma + 1) (w/a_o)^2 \\ + (1/12) (\gamma + 1) (w/a_o)^3 ] \end{aligned} \quad (3)$$

Following a suggestion of Morgan, Huckel, and Runyan,<sup>2</sup> we may generalize this result, Eq. (3), by writing

$$C_p = (2/M^2) [ C_1(w/a_o) + C_2(w/a_o)^2 + C_3(w/a_o)^3 ] \quad (4)$$

in which for piston theory

$$C_1 = 1, \quad C_2 = (\gamma + 1)/4, \quad C_3 = (\gamma + 1)/12 \quad (5)$$

and for the quasi-steady theory of Van Dyke<sup>3</sup>

$$C_1 = M/\beta, \quad C_2 = [M^4(\gamma + 1) - 4\beta^2]/4\beta^4, \quad C_3 = (\gamma + 1)/12 \quad (6)$$

Van Dyke gives only the second-order solution so that the value of  $C_3$  is taken from the piston theory result. The use of the modified coefficients  $C_1$  and  $C_2$  could extend the lower Mach number limit of piston theory.

We may now calculate the lifting pressure coefficient from Eq. (4) and the local piston velocity. The normal velocity (positive away from the surface) on the upper and lower surfaces of a symmetrical thin airfoil having thickness distribution  $2g(x)$  and angle of attack  $\alpha_o$  is given by

$$w_u = V(g_x - \alpha_o - v) \quad , \quad (7a)$$

$$w_l = V(g_x + \alpha_o + v) \quad , \quad (7b)$$

where  $v$  is the unsteady component of the dimensionless downwash.

For the case of small angles of attack, the lifting pressure (positive down) is

$$\begin{aligned} C_p = C_{p_u} - C_{p_l} &= - (4/M) [(C_1 + 2C_2 Mg_x \\ &\quad + 3C_3 M^2 g_x^2) (\alpha_o + v) + C_3 M^2 (\alpha_o + v)^3] \end{aligned} \quad . \quad (8)$$

If, consistent with the small perturbation assumptions of aeroelastic analysis, only the terms linear in  $v$  are retained, Eq. (8) becomes

$$C_p = - (4v/M) [C_1 + 2C_2 Mg_x + 3C_3 M^2 (g_x^2 + \alpha_o^2)] \quad . \quad (9)$$

Before discussing the swept wing transformation, it is appropriate to review the limitations of Eq. (9). Ashley and Zartarian<sup>1</sup> have shown that the piston theory is applicable if any of the conditions  $M^2 \gg 1$ ,  $Mk \gg 1$ , or

$k^2 >> 1$  is met. We see that for low reduced frequency the Mach number necessarily must be high. However, if the reduced frequency is large the Mach number is not necessarily large; in fact it could be transonic or even subsonic. At this point it is apparent that any sweep correction introduced to bring piston theory into line with linearized supersonic theory must be considered as a low frequency approximation.

The result, Eq. (9), applies to the swept wing case if all quantities are determined by the flow characteristics normal to the leading edge. The expressions may be rewritten in the form

$$\bar{C}_p = - (4\bar{v}/\bar{M}) [\bar{C}_1 + 2\bar{C}_2 \bar{M} \bar{g}_{\bar{x}} + 3\bar{C}_3 \bar{M}^2 (\bar{g}_{\bar{x}}^2 + \bar{a}_o^2)] \quad (10)$$

The transformation from the normal values to the free stream values are the following:

the Mach number

$$\bar{M} = M \cos \Lambda ; \quad (11a)$$

the geometry

$$\bar{x} = x \cos \Lambda ; \quad (11b)$$

$$\bar{b} = b \cos \Lambda ; \quad (11c)$$

the angles of attack and slope

$$\bar{a}_o = a_o / \cos \Lambda \quad (11d)$$

$$\bar{\beta} = \beta / \cos \Lambda \quad (11e)$$

$$\bar{g}_{\bar{x}} = g_x / \cos \Lambda ; \quad (11f)$$

the dynamic pressure

$$\bar{q} = q \cos^2 \Lambda ; \quad (11g)$$

and the pressure coefficient

$$C_p = \bar{C}_p \cos^2 \Lambda \quad (11h)$$

We note that  $h$  and  $k$  are invariant. From the dimensionless downwash

$$\begin{aligned} v = (1/V) \{ & h + V\alpha + (x - x_o)\dot{\alpha} \\ & + [V\beta + (x - x_h)\dot{\beta}] \underline{l}(x - x_h) \} \end{aligned} \quad (12)$$

which for harmonic motion becomes

$$\begin{aligned} v = ikh/b + [1 + i(k/b)(x - x_o)]\alpha \\ + [1 + i(k/b)(x - x_h)]\beta \underline{l}(x - x_h) \end{aligned} \quad (13)$$

we find the transformed value

$$\begin{aligned} \bar{v} = ikh/\bar{b} + [1 + i(k/\bar{b})(\bar{x} - \bar{x}_o)]\bar{\alpha} \\ + [1 + i(k/\bar{b})(\bar{x} - \bar{x}_h)]\bar{\beta} \underline{l}(\bar{x} - \bar{x}_h) \end{aligned} \quad (14a)$$

$$\begin{aligned} = ikh/b \cos \Lambda + [1 + i(k/b)(x - x_o)]\alpha / \cos \Lambda \\ + [1 + i(k/b)(x - x_h)](\beta / \cos \Lambda) \underline{l}(x - x_h) \end{aligned} \quad (14b)$$

$$= v / \cos \Lambda \quad (14c)$$

The transformed pressure coefficient becomes

$$C_p = \bar{C}_p \cos^2 \Lambda = [ -4(v/\cos \Lambda) \cos^2 \Lambda / M \cos \Lambda ] \\ \times [ \bar{C}_1 + 2\bar{C}_2 (M \cos \Lambda) (g_x/\cos \Lambda) \\ + 3\bar{C}_3 (M \cos \Lambda)^2 (g_x^2 + a_0^2)/\cos^2 \Lambda ] \quad (15a)$$

$$= -(4v/M) [ \bar{C}_1 + 2\bar{C}_2 Mg_x + 3C_3 M^2 (g_x^2 + a_0^2) ] \quad (15b)$$

We note that the sweep effect shows up only in the coefficients  $\bar{C}_1$  and  $\bar{C}_2$ ; for piston theory, there is no effect

$$\bar{C}_1 = C_1 = 1, \quad \bar{C}_2 = C_2 = (\gamma + 1)/4 \quad , \quad (16)$$

and for the quasi-steady supersonic theory

$$\bar{C}_1 = M/(M^2 - \sec^2 \Lambda)^{1/2} \quad , \\ \bar{C}_2 = [ M^4(\gamma + 1) - 4 \sec^2 \Lambda (M^2 - \sec^2 \Lambda) ] / [ 4(M^2 - \sec^2 \Lambda)^2 ] \quad . \quad (17)$$

Equation (17) is seen to be the most general result. If  $\sec \Lambda$  is taken as zero then the piston theory results, Eqs. (16), are obtained; and if  $\sec \Lambda$  is taken as unity the sweep correction is not made in the quasi-steady supersonic result.

We next consider the integration of the pressure coefficients obtained above. The oscillatory aerodynamic coefficients referred to the leading edge are defined by the following equations.

$$dL/dy = 4\rho\omega^2 b^3 \left( L_{h_o} h_o/b + L_{a_o} a + L_{\beta_o} \beta \right) \quad (18a)$$

$$dM/dy = 4\rho\omega^2 b^4 \left( M_{h_o} h_o/b + M_{a_o} a + M_{\beta_o} \beta \right) \quad (18b)$$

$$dT/dy = 4\rho\omega^2 b^4 \left( T_{h_o} h_o/b + T_{a_o} a + T_{\beta_o} \beta \right) \quad (18c)$$

The lift, moment, and hinge moment are found from the pressure coefficient

$$dL/dy = q \int_0^{2b} C_p dx \quad (19a)$$

$$dM/dy = q \int_0^{2b} x C_p dx \quad (19b)$$

$$dT/dy = q \int_0^{2b} (x - x_h) C_p dx \quad (19c)$$

where the pressure coefficient is given by Eq. (15b).

$$C_p = -(4/M) \left[ \bar{C}_1 + 2\bar{C}_2 Mg_x + 3C_3 M^2 (g_x^2 + a_o^2) \right] \\ \times \left[ ikh_o/b + [1 + ikx/b] a + [1 + ik(x - x_h)/b] \beta \right] \underline{l(x - x_h)} \quad (20)$$

and we have taken the pitch axis at the leading edge  $x_o = 0$ . We define the following dimensionless thickness integrals

$$I_1 = (1/2b) \int_0^{2b} g_x dx \quad (21a)$$

$$I_2 = (1/4b^2) \int_0^{2b} x g_x dx \quad (21b)$$

$$I_3 = (1/8b^3) \int_0^{2b} x^2 g_x dx \quad (21c)$$

$$I_4 = (1/2b) \int_0^{2b} g_x^2 dx \quad (21d)$$

$$I_5 = (1/4b^2) \int_0^{2b} x g_x^2 dx \quad (21e)$$

$$I_6 = (1/8b^3) \int_0^{2b} x^2 g_x^2 dx \quad (21f)$$

$$J_1 = (1/2b) \int_{x_h}^{2b} g_x dx \quad (22a)$$

$$J_2 = (1/4b^2) \int_{x_h}^{2b} x g_x dx \quad (22b)$$

$$J_3 = (1/8b^3) \int_{x_h}^{2b} x^2 g_x dx \quad (22c)$$

$$J_4 = (1/2b) \int_{x_h}^{2b} g_x^2 dx \quad (22d)$$

$$J_5 = (1/4b^2) \int_{x_h}^{2b} x g_x^2 dx \quad (22e)$$

$$J_6 = (1/8b^3) \int_{x_h}^{2b} x^2 g_x^2 dx \quad (22f)$$

These thickness integrals are evaluated at the end of this section for a typical airfoil. If we substitute Eq. (20) into Eqs. (19), make use of the definitions Eqs. (21) and (22) of the thickness integrals, and identify the resulting expressions with Eqs. (18), we obtain the oscillatory aerodynamic coefficients

$$L_{h_o} = - iK_1/k \quad (23a)$$

$$L_{a_o} = - K_1/k^2 - iK_2/k \quad (23b)$$

$$L_{\beta_o} = - K_4/k^2 - i(K_5 - 2K_4\xi_h)/k \quad (23c)$$

$$M_{h_o} = - iK_2/k \quad (23d)$$

$$M_{a_o} = - K_2/k^2 - iK_3/k \quad (23e)$$

$$M_{\beta_o} = - K_5/k^2 - i(K_6 - 2K_5\xi_h)/k \quad (23f)$$

$$T_{h_o} = - i(K_5 - 2K_4\xi_h)/k \quad (23g)$$

$$T_{a_o} = -(K_5 - 2K_4\xi_h)/k^2 - i(K_6 - 2K_5\xi_h)/k \quad (23h)$$

$$T_{\beta_0} = - (K_5 - 2K_4 \xi_h)/k^2 - i(K_6 - 4K_5 \xi_h + 4K_4 \xi_h^2)/k \quad (23i)$$

where

$$\xi_h = x_h / 2b \quad (24a)$$

$$K_1 = (1/M) [\bar{C}_1 + 2\bar{C}_2 MI_1 + 3C_3 M^2(I_4 + a_o^2)] \quad (24b)$$

$$K_2 = (1/M) [\bar{C}_1 + 4\bar{C}_2 MI_2 + 3C_3 M^2(2I_5 + a_o^2)] \quad (24c)$$

$$K_3 = (4/3M) [\bar{C}_1 + 6\bar{C}_2 MI_3 + 3C_3 M^2(3I_6 + a_o^2)] \quad (24d)$$

$$K_4 = (1/M) \left\{ \bar{C}_1(1 - \xi_h) + 2\bar{C}_2 MJ_1 + 3C_3 M^2[J_4 + a_o^2(1 - \xi_h)] \right\} \quad (24e)$$

$$K_5 = (1/M) \left\{ \bar{C}_1(1 - \xi_h^2) + 4\bar{C}_2 MJ_2 + 3C_3 M^2[2J_5 + a_o^2(1 - \xi_h^2)] \right\} \quad (24f)$$

$$K_6 = (4/3M) \left\{ \bar{C}_1(1 - \xi_h^3) + 6\bar{C}_2 MJ_3 + 3C_3 M^2[3J_6 + a_o^2(1 - \xi_h^3)] \right\} \quad (24g)$$

To conclude the derivation of the oscillatory aerodynamic coefficients, we calculate the thickness integrals for the typical airfoil of Fig. 1. We approximate the airfoil by two parabolas and a line. The equation of the forward parabola that goes through the leading edge\* and is horizontal at the point of the maximum thickness is

$$g_1(x)/c = (\tau/2) (x/x_m) (2 - x/x_m) \quad (25)$$

---

\* The approximation by a sharp leading edge is consistent with the theory having ruled out detached shock waves.

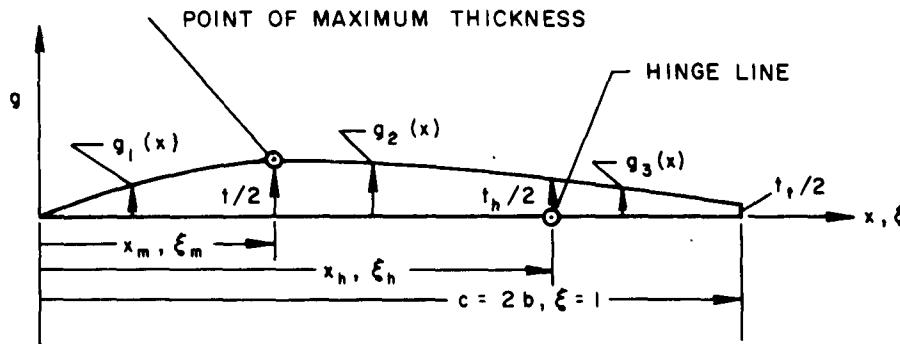


Fig. 1. Typical Airfoil Cross Section.

where  $\tau = t_{\max}/c$ . The second parabola, horizontal at the point of maximum thickness and going through the hinge line, is

$$g_2(x)/c = (\tau/2) \left\{ 1 - (1 - r_h) [(x - x_m)/(x_h - x_m)]^2 \right\} \quad (26)$$

where  $r_h = \tau_h/\tau$  and  $\tau_h = t_h/c$ . The line connecting the hinge line and blunt trailing edge is given by

$$g_3(x)/c = (\tau_h/2) [1 - (1 - r_t) (x - x_h)/(c - x_h)] \quad (27)$$

where  $r_t = \tau_t/\tau_h$  and  $\tau_t = t_t/c$ . By differentiating we find the desired slopes

$$g_1'(x)/c = (\tau/x_m) (1 - x/x_m) \quad (28a)$$

$$g_2'(x)/c = -\tau(1 - r_h)(x - x_m)/(x_h - x_m)^2 \quad (28b)$$

$$g_3'(x)/c = -(\tau_h/2)(1 - r_t)/(c - x_h) \quad (28c)$$

From the slopes, the thickness integrals follow immediately. Computing the control surface integrals first yields

$$J_1 = \int_{\xi_h}^1 g_\xi d\xi = -(1/2)(\tau_h - \tau_t) \quad (29a)$$

$$J_2 = \int_{\xi_h}^1 \xi g_\xi d\xi = -(1/4)(\tau_h - \tau_t)(1 + \xi_h) \quad (29b)$$

$$J_3 = \int_{\xi_h}^1 \xi^2 g_\xi d\xi = -(1/6)(\tau_h - \tau_t)(1 + \xi_h + \xi_h^2) \quad (29c)$$

$$J_4 = \int_{\xi_h}^1 g_\xi^2 d\xi = (1/4)(\tau_h - \tau_t)^2/(1 - \xi_h) \quad (29d)$$

$$J_5 = \int_{\xi_h}^1 \xi g_\xi^2 d\xi = (1/8)(\tau_h - \tau_t)^2(1 + \xi_h)/(1 - \xi_h) \quad (29e)$$

$$J_6 = \int_{\xi_h}^1 \xi^2 g_\xi^2 d\xi = (1/12)(\tau_h - \tau_t)^2(1 + \xi_h + \xi_h^2)/(1 - \xi_h) \quad (29f)$$

The complete airfoil integrals become

$$I_1 = \int_0^{\xi_h} g_\xi d\xi + J_1 = \tau_h/2 + J_1 \quad (30a)$$

$$I_2 = \int_0^{\xi_h} \xi g_\xi d\xi + J_2 = -(\tau/3)\xi_h + (\tau_h/6)(2\xi_h + \xi_m) + J_2 \quad (30b)$$

$$\begin{aligned} I_3 &= \int_0^{\xi_h} \xi^2 g_\xi d\xi + J_3 \\ &= (\tau/12)\xi_m^2 - (1/12)(\tau - \tau_h)(3\xi_h^2 + 2\xi_h\xi_m + \xi_m^2) + J_3 \end{aligned} \quad (30c)$$

$$I_4 = \int_0^{\xi_h} g_\xi^2 d\xi + J_4 = \tau^2/3\xi_m + (1/3)(\tau - \tau_h)^2/(\xi_h - \xi_m) + J_4 \quad (30d)$$

$$\begin{aligned} I_5 &= \int_0^{\xi_h} \xi g_\xi^2 d\xi + J_5 \\ &= \tau^2/12 + (1/12)(\tau - \tau_h)^2(3\xi_h + \xi_m)/(\xi_h - \xi_m) + J_5 \end{aligned} \quad (30e)$$

$$\begin{aligned} I_6 &= \int_0^{\xi_h} \xi^2 g_\xi^2 d\xi + J_6 \\ &= (\tau^2/30)\xi_m + (1/30)(\tau - \tau_h)^2(6\xi_h^2 + 3\xi_h\xi_m + \xi_m^2)/(\xi_h - \xi_m) + J_6 \end{aligned} \quad (30f)$$

where  $\xi = x/c$ ,  $\xi_m = x_m/c$ , and  $\xi_h = x_h/c$ .

Having obtained the oscillatory aerodynamic coefficients, we are now in a position to derive the AICs. We consider the given and equivalent force systems in Fig. 2. The equivalent forces are arbitrarily placed at the quarter-chord, the control surface hinge line, and the trailing edge. The derivation must relate the forces  $F_1$ ,  $F_2$ ,  $F_3$  to the deflections  $h_1$ ,  $h_2$ ,  $h_3$  through the given leading edge aerodynamic coefficients and deflections  $h_o$ ,  $a$ ,  $\beta$ . We begin with the force equivalence.

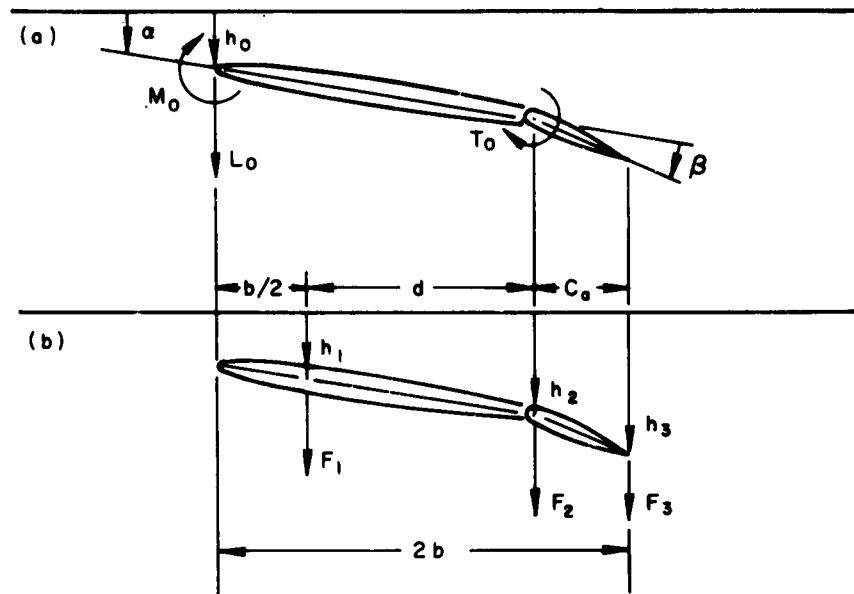
$$\begin{bmatrix} 1 & 1 & 1 \\ b/2 & (b/2 + d) & 2b \\ 0 & 0 & c_a \end{bmatrix} \begin{Bmatrix} F_1 \\ F_2 \\ F_3 \end{Bmatrix} = \begin{Bmatrix} L_o \\ M_o \\ T_o \end{Bmatrix} \quad (31)$$

The loads and deflections are related through the definitions of the oscillatory coefficients.

$$\begin{Bmatrix} L_o \\ M_o \\ T_o \end{Bmatrix} = 4\rho\omega^2 b^2 \Delta y \begin{bmatrix} 1 & 0 & 0 \\ 0 & b & 0 \\ 0 & 0 & b \end{bmatrix} \begin{bmatrix} L_{h_o} & L_{a_o} & L_{\beta_o} \\ M_{h_o} & M_{a_o} & M_{\beta_o} \\ T_{h_o} & T_{a_o} & T_{\beta_o} \end{bmatrix} \begin{Bmatrix} h_o \\ ba \\ b\beta \end{Bmatrix} \quad (32)$$

The equivalence in the deflections is given by

$$\begin{Bmatrix} h_o \\ ba \\ b\beta \end{Bmatrix} = \begin{bmatrix} (1 + b/2d) & -b/2d & 0 \\ -b/d & b/d & 0 \\ b/d & -(b/d + b/c_a) & b/c_a \end{bmatrix} \begin{Bmatrix} h_1 \\ h_2 \\ h_3 \end{Bmatrix} \quad (33)$$



**Fig. 2. Original (a) and Equivalent (b) Force Systems and Geometry for Oscillatory Case.**

Substituting Eq. (33) into (32), Eq. (32) into (31), and solving for the forces yields

$$\begin{aligned} \begin{Bmatrix} F_1 \\ F_2 \\ F_3 \end{Bmatrix} &= 4\rho\omega^2 b^2 \Delta y \begin{bmatrix} (1 + b/2d) & -b/d & (b/c_a)(3b/2d - 1) \\ -b/2d & b/d & -(b/c_a)(3b/2d) \\ 0 & 0 & b/c_a \end{bmatrix} \\ &\times \begin{bmatrix} L_{h_o} & L_{a_o} & L_{\beta_o} \\ M_{h_o} & M_{a_o} & M_{\beta_o} \\ T_{h_o} & T_{a_o} & T_{\beta_o} \end{bmatrix} \begin{bmatrix} (1 + b/2d) & -b/2d & 0 \\ -b/d & b/d & 0 \\ b/d & -(b/d + b/c_a) & b/c_a \end{bmatrix} \quad (34) \end{aligned}$$

From the definition of the AIC matrix

$$\{F\} = \rho\omega^2 b_r^2 s [C_h] \{h\}, \quad (35)$$

and by identity with Eq. (34), we find the AICs for a single strip.

$$\begin{aligned} [C_h] &= 4(b/b_r)^2 (\Delta y/s) \begin{bmatrix} (1 + b/2d) & -b/d & (b/c_a)(3b/2d - 1) \\ -b/2d & b/d & -(b/c_a)(3b/2d) \\ 0 & 0 & b/c_a \end{bmatrix} \\ &\times \begin{bmatrix} L_{h_o} & L_{a_o} & L_{\beta_o} \\ M_{h_o} & M_{a_o} & M_{\beta_o} \\ T_{h_o} & T_{a_o} & T_{\beta_o} \end{bmatrix} \begin{bmatrix} (1 + b/2d) & -b/2d & 0 \\ -b/d & b/d & 0 \\ b/d & -(b/d + b/c_a) & b/c_a \end{bmatrix} \quad (36) \end{aligned}$$

In the absence of a control surface Eq.(36) reduces to

$$[C_h] = 4(b/b_r)^2 (\Delta y/s) \begin{bmatrix} (1 + b/2d) & -b/d \\ -b/2d & b/d \end{bmatrix} \times \begin{bmatrix} L_{h_o} & L_{a_o} \\ M_{h_o} & M_{a_o} \end{bmatrix} \begin{bmatrix} (1 + b/2d) & -b/2d \\ -b/d & b/d \end{bmatrix} \quad (37)$$

The complete AIC matrix for a surface of N strips appears in the partitioned form

$$[C_h] = \begin{bmatrix} 0 & 0 & 0 & \cdot & \cdot & \cdot & 0 \\ 0 & C_{h1} & 0 & \cdot & \cdot & \cdot & 0 \\ 0 & 0 & C_{h2} & \cdot & \cdot & \cdot & 0 \\ \cdot & \cdot & \cdot & \cdot & & & \cdot \\ \cdot & \cdot & \cdot & \cdot & & & \cdot \\ \cdot & \cdot & \cdot & \cdot & & & \cdot \\ \cdot & \cdot & \cdot & \cdot & & & \cdot \\ 0 & 0 & 0 & \cdot & \cdot & \cdot & C_{hN} \end{bmatrix} \quad (38)$$

in which the first null partition is reserved for control points at which the aerodynamic forces are negligible (e.g., external stores) and in which the remaining partitions are of the size  $3 \times 3$  or  $2 \times 2$  according to whether or not the strip has a control surface.

The steady AIC matrix follows from the oscillatory solution as a limiting case. If we compare the definition of the steady matrix

$$\{F\} = (1/2)\rho V^2(S/\bar{C}) [C_{hs}] \{h\} \quad (39)$$

with the oscillatory definition Eq. (35), we observe

$$[C_{hs}] = 2(s\bar{C}/S) \lim_{k_r \rightarrow 0} k_r^2 [C_h] \quad (40)$$

From the previous section we find the limiting values of the oscillatory coefficients to be

$$\lim_{k_r \rightarrow 0} (k_r^2 L_{h_o}, k_r^2 M_{h_o}, k_r^2 T_{h_o}) = 0 \quad (41)$$

$$\lim_{k_r \rightarrow 0} k_r^2 L_{a_o} = - K_1 (b_r/b)^2 \quad (42a)$$

$$\lim_{k_r \rightarrow 0} k_r^2 M_{a_o} = - K_2 (b_r/b)^2 \quad (42b)$$

$$\lim_{k_r \rightarrow 0} k_r^2 T_{a_o} = - (K_5 - 2K_4 \xi_h) (b_r/b)^2 \quad (42c)$$

$$\lim_{k_r \rightarrow 0} k_r^2 L_{\beta_o} = - K_4 (b_r/b)^2 \quad (43a)$$

$$\lim_{k_r \rightarrow 0} k_r^2 M_{\beta_0} = - K_5 (b_r/b)^2 \quad (43b)$$

$$\lim_{k_r \rightarrow 0} k_r^2 T_{\beta_0} = - (K_5 - 2K_4 \xi_h) (b_r/b)^2 \quad (43c)$$

#### D. References

1. H. Ashley and G. Zartarian. "Piston Theory--A New Aerodynamic Tool for the Aeroelastician." Journal of the Aeronautical Sciences, 23 (1956), 1109.
2. H. G. Morgan, V. Huckel, and H. L. Runyan. "Procedure for Calculating Flutter at High Supersonic Speed Including Camber Deflections, and Comparison with Experimental Results." NACA TN 4335, September 1958.
3. M. D. Van Dyke. "A Study of Second-Order Supersonic Flow Theory." NACA Report 1081, 1952.
4. W. P. Rodden, E. F. Farkas, P. E. Williams, and F. C. Slack. "Aerodynamic Influence Coefficients by Piston Theory: Analytical Development and Procedure for the IBM 7090 Computer." Northrop Corporation Report NOR-61-57, 14 April 1961.
5. J. W. Miles. The Potential Theory of Unsteady Supersonic Flow. London: Cambridge University Press, 1959, pp. 184-185.

## SECTION II

### GENERAL DESCRIPTION OF INPUT

#### A. Units

Since all dimensional input is geometrical and the aerodynamic matrix is dimensionless, only a consistent set of length units is necessary--inches or feet.

#### B. Classes of Numerical Data and Limitations

The data required by the program are control and option indicators, geometry, Mach numbers, and a set of reduced velocities for each Mach number. The example problem illustrates their use.

##### 1. Example Problem

We consider the four-strip wing shown in Fig. 3 at Mach numbers 1.8 and 2.5. We use reduced velocities of 4.0 and 8.0 for both Mach numbers, and compute the steady case for Mach 2.5. The aerodynamic matrices will be computed by piston theory and by Van Dyke's quasi-steady variation. Strips 2 and 3 are considered to have control surfaces. The thickness integrals will be computed for an assumed airfoil (constant across the span) having 10 percent thickness, maximum thickness at 40 percent chord, and a blunt trailing edge having 1.5 percent thickness.

##### 2. Program Restrictions and Options

- a. The number of strips into which a wing may be subdivided must be  $\leq 25$ .
- b. The number of Mach numbers must be  $\leq 15$ .
- c. The number of reduced velocities used with any one Mach number must be  $\leq 20$ .

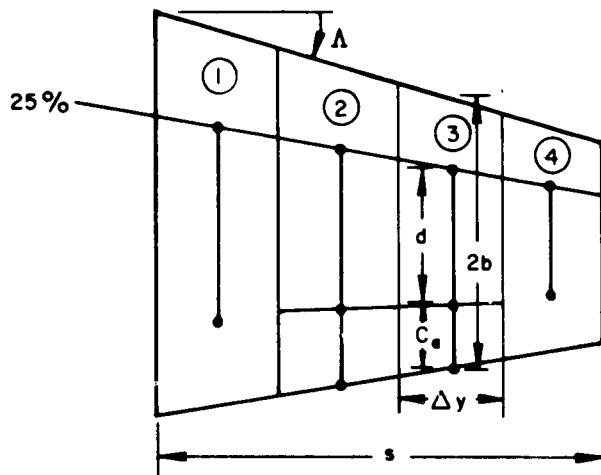


Fig. 3. Example of Four-Strip Wing.

Strip No.	$\Delta y$ (ft)	b(ft)	$c_a$ (ft)	d(ft)
1	4.7	12.28120	0	11.9
2	4.2	9.50000	5.25000	9.0
3	3.6	7.06250	3.99375	6.6
4	3.1	4.96875	0	4.5

Strip No.	$\xi_m$	$\xi_h$	$\tau$	$\tau_h$	$\tau_t$
1	0.4	(not used)	0.1	0.015*	(not used)
2	0.4	0.72368421	0.1	0.050	0.015
3	0.4	0.71725664	0.1	0.050	0.015
4	0.4	(not used)	0.1	0.015*	(not used)

$\sec \Lambda = 1.25$        $S = 554.0 \text{ sq ft}$   
 $b_r = 6.5 \text{ ft}$        $\bar{c} = 21.0 \text{ ft}$   
 $s = 15.6 \text{ ft}$        $a_o$ 's (constant) =  $5.0^\circ$

\* N.B. The trailing edge thickness is listed as the hinge line thickness in the case of no control surface.

d. If it is desired to compute the steady matrix  $[C_{hs}]$ , a zero or negative value of  $V/b_r \omega$  must be supplied to the program. ( $S$  and  $\bar{c}$  must also be provided.)

e. Thickness integrals may be given or computed. If given they may be given only once with each deck and are considered constant with strips.  $a_o$ 's may be constant or vary with strips (for each Mach number).  $(\tau, \tau_h, \tau_t)$ 's may be constant or vary with strips.  $\xi_m$  and  $\xi_h$  may be constant or vary with strips.

f. The control surface strips must be a continuation of the main surface strips; e. g., in the case of a partial span control surface the inboard and outboard span stations should be used as boundaries of the main surface strips.

g. As many complete sets (decks) of input data may be supplied as desired (one following the other).

SECTION III  
DATA DECK SETUP

A. Loading Order

Input decks punched from keypunch forms are loaded behind column binary deck HM11. The data for each deck should be in the following order:

- (1) Heading Card 1
- (2) Heading Card 2
- (3) NTHRY, NTHICK, NALPHA, NTAUS, NZETAS \*
- (4) ISZ, MSZ, NO PUNJ, JSZ<sub>1</sub>, JSZ<sub>2</sub>, . . . JSZ<sub>MSZ</sub>
- (5) sec Λ, b<sub>r</sub>, s, S,  $\bar{c}$
- (6) Δy<sub>1</sub>, Δy<sub>2</sub>, . . . , Δ<sub>ISZ</sub>
- (7) b<sub>1</sub>, b<sub>2</sub>, . . . , b<sub>ISZ</sub>
- (8) c<sub>a1</sub>, c<sub>a2</sub>, . . . , c<sub>aISZ</sub>
- (9) d<sub>1</sub>, d<sub>2</sub>, . . . , d<sub>ISZ</sub>
- (10) Mach<sub>1</sub>, Mach<sub>2</sub>, . . . , Mach<sub>MSZ</sub>
- (11a) If thickness integrals are given:
  - (a) When all c<sub>ai</sub> = 0 tabulate only I<sub>1</sub>, I<sub>2</sub>, . . . , I<sub>6</sub>.
  - (b) Any c<sub>ai</sub> ≠ 0 then include J<sub>1</sub>, J<sub>2</sub>, . . . , J<sub>6</sub>, and  $\xi_{h1}$ ,  $\xi_{h2}$ , . . . ,  $\xi_{hISZ}$  (if NZETAS = 1 only  $\xi_{h1}$  is needed).
- (11b) If thickness integrals are computed:
  - (a)  $\tau_1$ ,  $\tau_{h1}$ ,  $\tau_{t1}$ ;  $\tau_2$ ,  $\tau_{h2}$ ,  $\tau_{t2}$ ; . . . ;  $\tau_{ISZ}$ ,  $\tau_{hISZ}$ ,  $\tau_{tISZ}$   
[if NTAUS = 1 only  $\tau_1$ ,  $\tau_{h1}$ , and  $\tau_{t1}$  are needed; if c<sub>ai</sub> = 0 (i. e., no control surface), the trailing edge thickness ( $\tau_{ti}$ ) is listed as  $\tau_{hi}$ , and the location for  $\tau_{ti}$  may be left blank for these strips].

---

\*Please, no remarks about our Greek!

(b)  $\xi_{m1}, \xi_{h1}; \xi_{m2}, \xi_{h2}; \dots; \xi_{mISZ}, \xi_{hISZ}$  [if NZETA = 1  
only  $\xi_{m1}$  and  $\xi_{h1}$  are needed; if  $c_{ai} = 0$ , the program  
uses  $\xi_h = 1.0$  ( $\xi$  for trailing edge), and the location  
for  $\xi_{hi}$  may be left blank for these strips].

(12a) If alphas do not vary with strips:

$a_1, a_2, \dots, a_{MSZ}$

(12b) If alphas vary with strips:

(a)  $a_1, a_2, \dots, a_{ISZ}$  for first Mach number

(b)  $a_1, a_2, \dots, a_{ISZ}$  for second Mach number

(c)  $a_1, a_2, \dots, a_{ISZ}$  for MSZ Mach number

(13)  $V/b_r \omega$  series

(a)  $(V/b_r \omega)_1, (V/b_r \omega)_2, \dots, (V/b_r \omega)_{JSZ}$  for first Mach  
number

(b)  $(V/b_r \omega)_1, (V/b_r \omega)_2, \dots, (V/b_r \omega)_{JSZ}$  for second Mach  
number

(c)  $(V/b_r \omega)_1, (V/b_r \omega)_2, \dots, (V/b_r \omega)_{JSZ}$  for MSZ Mach  
number

## B. Input Data Description

(1), (2) Heading Card 1 and Heading Card 2 may contain any characters desired in Columns 2 through 72. These cards are convenient for identifying the vehicle, surface, date, engineer, etc. Both cards may be blank but must be included in the data deck.

(3) Control card: FORMAT (18I4)

(a) NTHRY = 0, piston theory is used to compute  $C_1$  and  $C_2$

NTHRY  $\neq$  0, Van Dyke's theory is used to compute  $C_1$  and  $C_2$  (If  $\sec \Lambda = 0$ , then with either theory  $C_1$  and  $C_2$  are the same)

- (b) NTHICK = 0, when thickness integrals are computed  
NTHICK  $\neq$  0, when thickness integrals are given (in this case they are constant for the surface)
- (c) NALPHA = 1, the alphas are constant (do not vary with each strip)  
NALPHA = ISZ, the alphas vary with each strip
- (d) NTAUS = 1, the  $\tau$ ,  $\tau_h$ , and  $\tau_t$  are constant for all strips  
NTAUS = ISZ, the  $\tau$ ,  $\tau_h$ , and  $\tau_t$  vary with each strip
- (e) NZETAS = 1,  $\xi_m$  and  $\xi_h$  are constant for all strips  
NZETAS = ISZ,  $\xi_m$  and  $\xi_h$  vary with each strip

(4) Control card: FORMAT (18I4)

- (a) ISZ = number of strips,  $\leq 25$
- (b) MSZ = number of Mach numbers,  $\leq 15$
- (c) NO PUNJ = 0, or blank, when punched card output is desired  
NO PUNJ  $\neq$  0, no punched output is desired
- (d) JSZ<sub>1</sub> = number of  $(V/b_r \omega)$ 's for first Mach number,  $\leq 20$   
JSZ<sub>2</sub> = number of  $(V/b_r \omega)$ 's for second Mach number,  
 $\leq 20$   
.  
.  
.  
JSZ<sub>MSZ</sub> = number of  $(V/b_r \omega)$ 's for last Mach number,  $\leq 20$

(5) Single parameters: FORMAT (6E12.8)

- (a) sec  $\Lambda$ , secant of leading edge sweep angle
- (b)  $b_r$ , reference semichord

- (c)  $s$ , wing semispan
- (d)  $S$ , wing area
- (e)  $\bar{c}$ , mean aerodynamic chord
- (6)  $\Delta y_i$  series: FORMAT (6E12.8)  
 $\Delta y_1 \dots \Delta y_{ISZ}$ , strip widths
- (7)  $b_i$  series: FORMAT (6E12.8)  
 $b_1 \dots b_{ISZ}$ , local semichords
- (8)  $c_{ai}$  series: FORMAT (6E12.8)  
 $c_{a1} \dots c_{aISZ}$ , control surface chords; in the absence of a control surface,  $c_{ai}$  may be zero or blank, but a sufficient number of cards must be included
- (9)  $d_i$  series: FORMAT (6E12.8)  
 $d_1 \dots d_{ISZ}$ , distance between forward and aft control points
- (10) Mach number series: FORMAT (6E12.8)  
 $Mach_1 \dots Mach_{MSZ}$ , in any order desired, but the number listed must agree with MSZ
- (11a) Thickness integrals given: FORMAT (6E12.8)
  - (a)  $I_1, I_2, \dots, I_6$ , the complete airfoil thickness integrals
  - (b)  $J_1, J_2, \dots, J_6$ , the control surface thickness integrals, use only when  $c_{ai} \neq 0$   
 $\xi_{h1}, \xi_{h2}, \dots, \xi_{hISZ}$ , dimensionless chordwise coordinate ( $x_h/c$ ) for the control surface hinge line
- (11b) Thickness integrals are computed: FORMAT (6E12.8)
  - (a)  $\tau_i$ ,  $\tau_{hi}$ , and  $\tau_{ti}$ , airfoil thickness ratios ( $t/c$ ) at point of maximum thickness, hinge line, and trailing edge, respectively

(b)  $\xi_{mi}$  and  $\xi_{hi}$ , dimensionless chordwise coordinates for point of maximum thickness and hinge line

(12a) Alphas do not vary with strips (alpha is  $\alpha_0$ , the initial angle of attack). FORMAT (6E12.8)

$\alpha_1, \alpha_2, \dots, \alpha_{MSZ}$  (degrees) are tabulated in order for each Mach number

(12b) Alphas vary with strips: FORMAT (6E12.8)

$\alpha_1, \alpha_2, \dots, \alpha_{ISZ}$  (degrees) are tabulated for each Mach number. The series for each Mach number starts on a new line (card).

(13)  $V/b_r \omega$  series, reference reduced velocity: FORMAT (6E12.8)

There is a reduced velocity series for each Mach number; each series starts on a new line (card), and the number of  $V/b_r \omega$ 's must agree with the JSZ for the respective Mach number.

### C. Example Keypunch Forms

Example keypunch forms are given on the following pages. Columns 73 through 80 are reserved for data deck identification. This space may be used in any fashion; however, it is suggested that the last three columns be used for sequencing. Only the cards with sequencing in Columns 73 through 80 are to be used in the sample data deck; the lines (cards) with Columns 73 through 80 blank are for clarification of input.



sec A	b <sub>1</sub>	b <sub>2</sub>	b <sub>3</sub>	b <sub>4</sub>	b <sub>5</sub>	b <sub>6</sub>	c	
1.25	6.5	15.6	55.4.0	21.0			H M I I 0 0 0 5	
$\Delta y_1$	$\Delta y_2$	$\Delta y_3$	$\Delta y_4$	$\Delta y_5$	$\Delta y_6$			
4.7	4.2	3.6	3.1				H M I I 0 0 0 6	
c <sub>a</sub> <sub>1</sub>	c <sub>a</sub> <sub>2</sub>	c <sub>a</sub> <sub>3</sub>	c <sub>a</sub> <sub>4</sub>	c <sub>a</sub> <sub>5</sub>	c <sub>a</sub> <sub>6</sub>		H M I I 0 0 0 7	
0	5.25	3.99375	0				H M I I 0 0 0 8	
d <sub>1</sub>	d <sub>2</sub>	d <sub>3</sub>	d <sub>4</sub>	d <sub>5</sub>	d <sub>6</sub>		H M I I 0 0 0 9	
1.1.9	9.	6.6	4.5				H M I I 0 0 1 0	
Mach <sub>1</sub>	Mach <sub>2</sub>	Mach <sub>3</sub>	Mach <sub>4</sub>	Mach <sub>5</sub>	Mach <sub>6</sub>			
1.8	2.5							
$\tau_1$	$\tau_{h1}$	$\tau_{t1}$	$\tau_2$	$\tau_{h2}$	$\tau_2$			
$\tau_3$	$\tau_{h3}$	$\tau_{t3}$	$\tau_4$	$\tau_{h4}$	$\tau_4$			
-	.05	.015	.1	.015	.015			
$\xi_m$	$\xi_{h1}$	$\xi_{m2}$	$\xi_{n2}$	$\xi_{m3}$	$\xi_{h3}$			
4		72368421		4			H M I I 0 0 1 3	
1.2.3.4.5.6.7.8.9.10.11.12.13.14.15.16.17.18.19.20.21.22.23.24.25.26.27.28.29.30.31.32.33.34.35.36.37.38.39.40.41.42.43.44.45.46.47.48.49.50.51.52.53.54.55.56.57.58.59.60.61.62.63.64.65.66.67.68.69.70.71.72.73.74.75.76.77.78.79.70.71.72.73.74.75.76.77.78.79.70								

The second case is identical except for the following card (Van Dyke's

## SECTION IV

### PROGRAM OUTPUT

#### A. Printed Output

1. All input data
2. Thickness integrals (I's and J's)
3. Each group of aerodynamics influence coefficients (comprising a complete aerodynamic matrix), associated Mach number, and  $V/b_r \omega$
4. Sequencing numbers (Columns 73 through 80) of the first and last punched cards (output) for each group (one  $V/b_r \omega$ ) of influence coefficients
5. Example problem printed output is shown on the following pages

AERODYNAMIC INFLUENCE COEFFICIENTS BY PISTON THEORY

INPUT DATA

4 STRIPS  
2 MACH NUMBERS  
5 REDUCED FREQUENCIES (TOTAL)

SECANT LAMBDA = 0.124999999E 01  
BB = 0.665999999E 01  
S = 0.15600000E 02  
\$ = 0.55400000E 03  
C BAR = 0.20999999E 02

STRIP : 1 2 3 4  
DELTALAMBDA : 0.00000000E 00

	STRIP	X1 H	X2 H	TAU U	TAU H	TAU U	TAU H
1	0.46999999E 01	0.12281200E 02	0.	0.52499999E 01	0.11900000E 02	0.	0.89999999E 01
2	0.41999999E 01	0.95000000E 01	0.95000000E 01	0.39937499E 01	0.65999999E 01	0.45000000E 01	0.15000000E -01
3	0.35999999E 01	0.70625000E 01	0.49607500E 01	0.	0.	0.	0.
4	0.30999999E 01	0.49607500E 01	0.	0.	0.	0.	0.

STRIP : 1 2 3 4  
X1 H : 0.00000000E 00  
X2 H : 0.00000000E 00  
TAU U : 0.00000000E 00  
TAU H : 0.00000000E 00

	STRIP	X1 H	X2 H	TAU U	TAU H	TAU U	TAU H
1	0.40000000E -00	0.09999999E 01	0.09999999E -00	0.09999999E -00	0.15000000E -01	0.	0.
2	0.40000000E -00	0.72368421E 00	0.09999999E -00	0.49999999E -01	0.	0.15000000E -01	0.
3	0.35000000E -00	0.11756641E 00	0.09999999E -00	0.65999999E -01	0.	0.15000000E -01	0.
4	0.30000000E -00	0.09999999E 01	0.09999999E 00	0.15000000E -01	0.	0.	0.

	STRIP	X1 H	X2 H	TAU U	TAU H	TAU U	TAU H
1	0.40000000E 00	0.40000000E 01	0.80000000E 01	0.40000000E 01	0.40000000E 01	0.80000000E 01	0.40000000E 01
2	0.35000000E 00	0.50000000E 01	0.80000000E 01	0.50000000E 01	0.50000000E 01	0.80000000E 01	0.50000000E 01
3	0.30000000E 00	0.50000000E 01	0.50000000E 00	0.	0.	0.	0.
4	0.25000000E 00	0.50000000E 01	0.	0.	0.	0.	0.

	STRIP	X1 H	X2 H	TAU U	TAU H	TAU U	TAU H
1	0.40000000E 00	0.40000000E 01	0.80000000E 01	0.40000000E 01	0.40000000E 01	0.80000000E 01	0.40000000E 01
2	0.35000000E 00	0.50000000E 01	0.80000000E 01	0.50000000E 01	0.50000000E 01	0.80000000E 01	0.50000000E 01
3	0.30000000E 00	0.50000000E 01	0.	0.	0.	0.	0.
4	0.25000000E 00	0.50000000E 01	0.	0.	0.	0.	0.

		INTERFACES					
		INTERFACES					
STRIP	J(1)	J(2)	J(3)	J(4)	J(5)	J(6)	
1	0.	0.	0.	0.	0.	0.	
2	0.7500000E-02	0.7500000E-02	0.7500000E-02	0.7500000E-02	0.7500000E-02	0.7500000E-02	
3	0.7500000E-02	0.7500000E-02	0.7500000E-02	0.7500000E-02	0.7500000E-02	0.7500000E-02	
4	0.	0.	0.	0.	0.	0.	
STRIP	I(1)	I(2)	I(3)	I(4)	I(5)	I(6)	
1	0.7500000E-02	0.7500000E-02	0.7500000E-02	0.7500000E-02	0.7500000E-02	0.7500000E-02	
2	0.7500000E-02	0.7500000E-02	0.7500000E-02	0.7500000E-02	0.7500000E-02	0.7500000E-02	
3	0.7500000E-02	-0.23646939E-01	-0.21173231E-01	0.96808512E-02	0.34390200E-02	0.20179822E-02	
4	0.7499999E-02	-0.27333333E-01	-0.26716666E-01	0.97783331E-02	0.42451386E-02	0.30875553E-02	

AERODYNAMIC INFLUENCE COEFFICIENTS BY PISTON THEORY

3

INITIAL GASE

MACH = 1.000000000

1/K(R) = 0.40000000E 01

ESTIMATES

CH(1) SIZE = 2 BY 2

0.71788753E 01	-0.39289374E 011	-0.71788753E 01	0.64322150E 001
0.44294456E 01	0.64322149E 001	-0.44294456E 01	-0.26705447E 011

CH(2) SIZE = 3 BY 3

0.71788753E 01	-0.39289374E 011	-0.71788753E 01	0.64322150E 001
0.44294456E 01	0.64322149E 001	0.44294456E 001	-0.26705447E 011
-0.	-0.	1	0.21198682E 01

-0.14268376E-001 -0.21198682E 01 -0.28536656E-001

CH(3) SIZE = 3 BY 3

0.69116519E 01	-0.316911650E 011	-0.63116501E 01	0.58473492E 001
0.89333970E 00	0.13913970E 001	0.92339369E 001	-0.85239369E 001
-0.	0.13913970E 001	0.31325322E-001	-0.31325322E-001

CH(4) SIZE = 2 BY 2

0.48474802E 01	-0.10759194E 011	-0.48474802E 01	0.23693249E-001
0.33333333E 01	0.33333333E-001	0.33333333E 01	-0.33333333E-001

PUNCHED CARDS NBS. MACH = 0 THRU MACH 12

AERODYNAMIC INFLUENCE COEFFICIENTS BY PISTON THEORY

OSCILLATORY CASE

MACH = 1.800000000

$$1/KIR) = 0.80000000E 01$$

RESULTS

CH(1) SIZE = 2 BY 2

0.28715501E 02	-0.78578748E 011	-0.28715501E 02	0.12864430E 011
0.17717782E 02	0.12864430E 011	-0.17717782E 02	-0.53410894E 011

CH(2) SIZE = 3 BY 3

0.30000000E 02	-0.20000000E 011	0.3230214531E 02	0.431081920E 001	-0.18888477E -016	0.38887660E 001
0.23300000E 02	0.23300000E 001	0.317263139E 011	-0.17274580E 011	-0.389194699E 011	-0.28386794E 001
-0.	-0.	1	0.84794731E 01	-0.28536753E -001	-0.84794731E 01

CH(3) SIZE = 3 BY 3

0.34000000E 02	0.34000000E 011	0.377446800E 02	0.277495068E 001	-0.23974891E -016	0.318874755E 001
0.27000000E 02	0.27000000E 001	0.318956369E 011	-0.11847871E 011	-0.174962383E 011	-0.186661093E -001
-0.	-0.	1	0.18005984E 01	-0.18005984E 001	-0.18005984E 001

CH(4) SIZE = 2 BY 2

0.19389921E 02	-0.21518388E 011	-0.19389921E 02	0.47386498E -001
0.13530000E 02	0.13530000E 001	-0.13530000E 011	-0.13530000E 001

PLUNGED CYCLES NEXT THREE THRU HILL 25

AERODYNAMIC INFLUENCE COEFFICIENTS BY PISTON THEORY

5

Oscillatory Case

MACH = 2.500000000

1/K(R) = 0.400000000E 01

ASTRIELS

CH(1) SIZE = 2 BY 2  
 0.57621686E 01 -0.314588882E 011 -0.57621686E 01 0.50858803E 001  
 0.28960149E 01 0.50858802E 001 -0.28960149E 01 -0.18340717E 011

CH(2) SIZE = 3 BY 3  
 0.257071110E 01 -0.23131730E 011 -0.456877530E 01 0 -0.200010731E -001 0 -0.38767660E -01 0 -0.58113979E -001  
 0.507751119E 00 -0.200010731E -001 0.66290539E 60 -0.662905329E 001 -0.14103174E 01 -0.38997485E -011  
 -0. 0.21424233E -081 0.147081177E 01 -0.98997386E -011 -0.147081177E 01 -0.19799466E -001

CH(3) SIZE = 3 BY 3

0.15474671E 01 -0.11624639E 011 -0.31177289E 01 0 0.11313956E 001 -0.15793156E -001 -0.17947514E -001  
 0.200010731E -001 0.11313956E 00 -0.380731376E 001 0 0.126660910E 001 -0.46825900E -001  
 -0. 0.11313956E 001 -0.61111431E 00 -0.61111431E 001 -0.126660910E 01 -0.29651180E -001

CH(4) SIZE = 2 BY 2  
 0.392333785E 01 -0.86084867E 001 -0.392333785E 01 0.18180238E -001

PUBLISHED CARS3 NOS5 - HB11 - 26 THRU 44411 31

## AERODYNAMIC INFLUENCE COEFFICIENTS BY PISTON THEORY

OSCILLATORY CASE

DATE = 7-10-1968 0000

1/K(R) = 0.00000000E 01

\*STRINGS

CH(1) SIZE = 2 BY 2

0.23048674E 02	-J-62917764E 011	-0.23048674E 02	0.10171760E 011
0.11584059E 02	0.10171760E 011	-0.11584059E 02	-0.36681435E 011

0.42848467E-081	0.58832709E 01	-0.19799477E-001	-0.58832709E 01
0.74318711E-091	0.31196219E-011	-0.12170660E 011	-0.58832709E 01
-0.	0.42848467E-081	0.58832709E 01	-0.39598934E-001

CH(3) SIZE = 3 BY 3

0.19344711E 02	-0.11715210E 011	-0.11715210E 001	-0.35895152E-001
0.71402581E-07	0.11715210E 011	0.71402581E 001	0.29855152E-001
0.	0.11715210E 011	0.11715210E 001	-0.29855152E-001

CH(4) SIZE = 2 BY 2

0.15693514E 02	-0.17216273E 011	-0.15693514E 02	0.36360475E-001
0.11559314E 01	0.16889475E-001	-0.87459339E 01	-0.11204433E 011

PUNCHED CARDS NO.5, FILE 1, 39 THRU 4801 51

AERODYNAMIC INFLUENCE COEFFICIENTS BY PISTON THEORY

7

STABILITY CASE

MACH = 2.5000000

1/K(R) = INFINITY

STRIPS

CH(1) SIZE = 2 BY 2

0.42592202E-00	-0.42592202E-00
0.21406464E-00	-0.21406464E-00

CH(2) SIZE = 3 BY 3

0.43102968E-00	-0.43102968E-00	0.206955879E-00
0.44991500E-01	0.61183333E-01	-0.10871838E-00
-0.	0.10871838E-00	-0.10871838E-00

CH(3) SIZE = 3 BY 3

0.39900692E-00	-0.39900692E-00	-0.11674341E-01
0.340111682E-01	0.56100000E-01	-0.931886374E-01
-0.	0.271101900E-01	-0.931886374E-01

CH(4) SIZE = 2 BY 2

0.29000423E-00	-0.29000423E-00
0.1616323E-00	-0.1616323E-00

FUNCTION CALLS NBS = 32 THRU MBL = 39

HM110686

4

**INTERACTION INFLUENCE COEFFICIENTS ON PISTON THEORY  
(WITH VAN DYKES QUASI-STADY THEORY FINAGLING FACTOR)**

## INPUT DATA

1 STRIPS  
2 MACH NUMBERS  
5 REDUCED FREQUENCIES (TOTAL)

SECANT LAMBDA = 0.12499999E 01  
 RR = 0.64389999E 01  
 S = 0.15660000E 02  
 T = 0.55100000E 03  
 C BAR = 0.20999999E 02

STRIP	DELTA Y (I)	B(I)	C(I)	D(I)
1	0.30000000E 01	0.122317200E 02	-0.	0.113666666E 02
2	0.35999999E 01	0.95000000E 01	0.526999999E 01	0.359999999E 01
3	0.35999999E 01	0.70625000E 01	0.39937499E 01	0.65999999E 01
4	0.30999999E 01	0.49687500E 01	-0.	0.45000000E 01

STRIP      R1 R      R1 N      TAU R      TAU N      TAU F

1	0.40000000E 00	0.099999999E 01	0.099999999E 00	0.150000000E -01	0.
2	0.40000000E 00	0.72368421E 00	0.099999999E 00	0.499999999E -01	0.150000000E -01
3	0.40000000E 00	0.71725664E 00	0.099999999E 00	0.499999999E -01	0.150000000E -01
4	0.40000000E 00	0.099999999E 01	0.099999999E 00	0.150000000E -01	0.

MACH NUMBER = 1.00000000  
 $1/A(R) = 0.46000000E 01$   
 $1/K(R) = 0.80000000E 01$   
 5.00      5.00      5.00

MACH NUMBER = 2.00000000

1/K(R) = 0.49999999E-01  
L/K(R) = 0.80000000E 01 9

ALPHA ZERO SERIES (DEGREES) = 5.00

5.00

COMPUTED INTEGRALS

STRIP	J(1)	J(2)	J(3)	J(4)	J(5)	J(6)
1	0.	0.	0.	0.	0.	0.
2	-0.17500000E-01	-0.11057231E-01	-0.71109350E-01	0.11083332E-02	0.95720021E-03	0.83075074E-03
3	-6.17500000E-01	-4.11011329E-01	-2.10031376E-01	0.100011467E-02	0.930011467E-03	0.80575106E-03
4	0.	0.	0.	0.	0.	0.

STRIP	I(1)	I(2)	I(3)	I(4)	I(5)	I(6)
1	0.74999999E-02	-0.72933333E-01	-0.24391666E-01	0.917783331E-02	0.42591666E-02	0.30875553E-02
2	0.75000000E-02	0.22933333E-01	0.721401949E-01	0.971114031E-02	0.34633333E-02	0.20313333E-02
3	0.75000000E-02	0.22333333E-01	0.7232117E-01	0.964008512E-02	0.34533333E-02	0.20113333E-02
4	0.74999999E-02	-0.27333333E-02	-0.26716666E-01	0.977833331E-02	0.42451386E-02	0.30875553E-02

AERODYNAMIC INFLUENCE COEFFICIENTS BY PISTON THEORY  
(WITH VAN DYKE'S QUASI-STADY THEORY FINAGLING FACTOR)

/o

ONE-POSITION CASE

MACH = 1.80000000

1/K(R) = 0.40000000E 01

45 FRAMES

CH(1) SIZE = 2 BY 2  
0.11171371E 02 -0.605000227E 011 -0.11171371E 02 0.93697202E 001  
0.49569440E 01 0.93697204E 001 -0.49569440E 01 -0.32057271E 011

CH(2) SIZE = 3 BY 3

0.4106923380E 02 -0.4106923380E 02 0.501160380E 001 -0.717609365E -011  
0.93588296E 00 0.40746372E -001 0.17310714E 01 -0.10904364E 011 -0.26669544E 01 -0.17950657E -001  
-0.32135350E -071 0.26669553E 01 -0.179506555E -001 -0.26669554E 01 -0.35901324E -001  
-0.

CH(3) SIZE = 3 BY 3

0.93588296E 01 0.386230173E 011 -0.926499537E 01 0.21086978E 001 -0.163118360E 01 0.538032920E -001  
0.73401403E 00 0.270869563E -001 0.157625398E 01 -0.169193279E 001 -0.23591163E 01 -0.1176014E -001  
-0.

CH(4) SIZE = 2 BY 2

0.11171371E 01 -0.11171371E 011 0.11171371E 01 0.331407074E 001  
0.331407074E 01 0.11171371E -001 -0.331407074E 01 -0.331407074E 001

PUNCHED CARDS NOS. HM11 60 THRU HM11 72

AERODYNAMIC INFLUENCE COEFFICIENTS BY PISSEN THEORY  
 (WITH VAN DYKES QUASI-STADY THEORY FINAGLING FACTOR)

Oscillatory Case

MACH = 1.80000000

1/K(R) = 0.80000000E 01

4310105

CH(1) SIZE = 2 BY 2  
 0.44685484E 02 -0.12100045E 021 -0.44685484E 02 0.18739440E 011  
 0.19827776E 02 0.18739440E 011 -0.19827776E 02 -0.64114542E 011

CH(2) SIZE = 3 BY 3  
 0.42716591E 02 -0.81173441E 011 -0.42716591E 02 0.81173441E 001 -0.31014738E 001 0.46521190E -071  
 0.37435318E 01 0.81492744E 001 0.69242857E 01 -0.21808727E 011 -0.10667817E 02 -0.35901315E -001  
 -0.64272700E -071 0.10667821E 02 -0.35901310E -001 -0.10667821E 02 -0.71802649E 001

CH(3) SIZE = 3 BY 3  
 0.35007581E 02 -0.520000243E 011 -0.35007581E 02 0.520000243E 001 -0.57432242E 07 0.10768545E -071  
 0.35007581E 01 0.520000243E 001 0.61171197E 01 -0.13918637E 011 -0.91965462E 01 -0.23544030E -001  
 -0. 0.16238585E -071 0.91965472E 01 -0.23544030E -001 -0.91965473E 01 -0.47088108E -001

CH(4) SIZE = 2 BY 2  
 0.30311763E 02 -0.31013001E 011 0.30311763E 02 0.31013001E 001 0.65556651E 02 0.65556651E 001  
 0.14365091E 02 0.34829511E 001 -0.19969911E 02 -0.19969911E 01

PUNCHED CARDS NOS. HM11 73 THRU HM11 85

AERODYNAMIC INFLUENCE COEFFICIENTS BY PISTON THEORY  
(WITH VAN DYKES QUASI-STADY THEORY FINAGLING FACTOR)

OSCILLATORY CASE

MACH = 2.5000000

1/K(R) = 0.4000000E 01

45INCHES

0.67178680E 01	-0.36588867E 01	0.67178680E 01	0.58417013E 001
0.32115138E 01	0.58417010E 001	-0.32115138E 01	-0.20540553E 011

0.64668594E 00	0.23948264E-001	0.1C177666E 01	-0.68747969E 001	-0.16646261E 01	-0.11204223E-001
-0.	-0.	1.0.16646264E 01	-0.11204222E-001	-0.16646265E 01	-0.22408430E-001

0.36200779E 01	-0.37019389E 011	-0.56206737E 01	0.15919369E-001	-0.12922239E-001	0.11937573E-001
0.64273030E 00	0.13919389E-001	0.3693716890E 00	-0.43939102E-001	-0.14336203E-001	0.73404239E-001
-0.	0.40596464E-001	0.14336210E 01	-0.73404244E-011	-0.14336210E 01	-0.14680822E-001

CH(3) SIZE = 3 BY 3

0.31177191E 01	-0.10000000E 01	-0.53000000E 01	0.3077710000E-001	0.62774219E-001
0.31177191E 01	0.30000000E 001	-0.23000000E 001	-0.23000000E 001	-0.62774219E-001

PUNCHED CARDS NOS. HM11 86 THRU HM11 98

13

AERODYNAMIC INFLUENCE COEFFICIENTS BY PISTON THEORY  
(WITH VAN DYKES QUASI-STEADY THEORY FINAGLING FACTOR)

OSCILLATORY CASE

MACH = 2.5000000

1/K(R) = 0.80000000E 01

4 STRIPS

		CH(1) SIZE = 2 BY 2
0.26871472E 02	-0.73177734E 011	-0.26871472E 02
0.12846056E 02	0.11683401E 011	-0.12846056E 02
<b>0.25874376E 01</b>	<b>0.47896529E-001</b>	<b>0.40710666E 01</b>
<b>-0.</b>	<b>-0.</b>	<b>0.66585060E 01</b>
		-0.22408444E-001
		-0.66585062E 01
		-0.44816859E-001
		-0.

		CH(2) SIZE = 3 BY 3
<b>0.25874376E 02</b>	<b>-0.35868260E 011</b>	<b>0.318963920E 001</b>
<b>0.25874376E 01</b>	<b>0.47896529E-001</b>	<b>-0.13749593E 011</b>
<b>-0.</b>	<b>-0.</b>	<b>1.</b>
		-0.22408444E-001
		-0.66585062E 01
		-0.44816859E-001
		-0.

CH(3) SIZE = 3 BY 3

		CH(4) SIZE = 2 BY 2
<b>0.25874376E 02</b>	<b>-0.324682693E 011</b>	<b>0.3119728E-001</b>
<b>0.25874376E 01</b>	<b>0.316231200E 001</b>	<b>-0.1994031E 001</b>
<b>-0.</b>	<b>-0.</b>	<b>1.</b>
		-0.1468084840E 01
		-0.57344840E 01
		-0.29361644E-001
		-0.

PUNCHED CARDS NOS. HM11 99 THRU HM11 111

AERODYNAMIC INFLUENCE COEFFICIENTS BY PISTON THEORY  
(WITH VAN DYKES QUASI-STADY THEORY FINAGLING FACTOR)

14

STEADY CASE

MACH = 2.50000000

1/K(R) = INFINITY

4 STRIPS

CH(1) SIZE = 2 BY 2  
0.49656443E-00 -0.49656443E-00  
0.23738536E-00 -0.23738536E-00

CH(2) SIZE = 3 BY 3  
0.47813884E-01 0.75230224E-01 -0.12304410E-00  
0.12304414E-00 -0.12304414E-00  
-0.

CH(3) SIZE = 3 BY 3  
0.0156613E-09 -0.0156613E-09 -0.12304410E-00  
0.0095250E-01 0.0095250E-01 -0.10596891E-00  
-0.

CH(4) SIZE = 2 BY 2

0.31079451E-09 -0.31079451E-09  
0.117922531E-09 -0.117922531E-09

PUNCHED CARDS NOS. HM11 112 THRU HM11 119

B. Punched Output

1. A deck of punched cards (output) from this program is suitable as an input deck to other programs requiring the use of AICs.
2. All punched output is sequenced in order on Columns 73 through 80 starting with HM110000. The data is punched in the following order:
  - a. Card 1 contains  $(V/b_r \omega)_1$  and  $M_1$ : FORMAT (6E12. 8)
  - b. Card 2 contains the size (number of control points) of the AIC matrix and the number of strips: FORMAT (18I4)
  - c. The AIC matrix punched in column binary form and its TRA card make up the remainder of the punched output for  $(V/b_r \omega)_1$
3. The order of Statement 2 above is repeated for all reduced velocities and associated Mach numbers per input deck.
4. Each AIC matrix is punched by columns. Column 1 starts in Origin 1 and Column 2 in Location (1 + matrix size).
5. The oscillatory AIC matrix is punched in the order -- Column 1 (real), Column 1 (imaginary), Column 2 (real), Column 2 (imaginary), . . . , Column N (real), Column N (imaginary). In the steady case all columns are real and are punched in order.

SECTION V  
PROCESSING INFORMATION

A. Operation

STANDARD FORTRAN MONITOR system

B. Estimated Machine Time

T = time in minutes

ISZ = number of strips

JSZM = total number of reduced velocities

MSZ = number of Mach numbers

n = number of sets (decks) of input data

$$T = 1.0 + .02 [(ISZ \cdot MSZ \cdot JSZM)_1 + (ISZ \cdot MSZ \cdot JSZM)_2 + \dots + (ISZ \cdot MSZ \cdot JSZM)_n]$$

C. Machine Components Used

Core storage, about 5300

Standard FORTRAN input tape (NTAPE 2)

Standard FORTRAN output print tape (NTAPE 3)

Standard FORTRAN output punch tape (NTAPE 7)

SECTION VI  
PROGRAM NOTES

A. Subroutines Used

RDLN, reads and prints title cards

AEROP4, punch AIC matrix

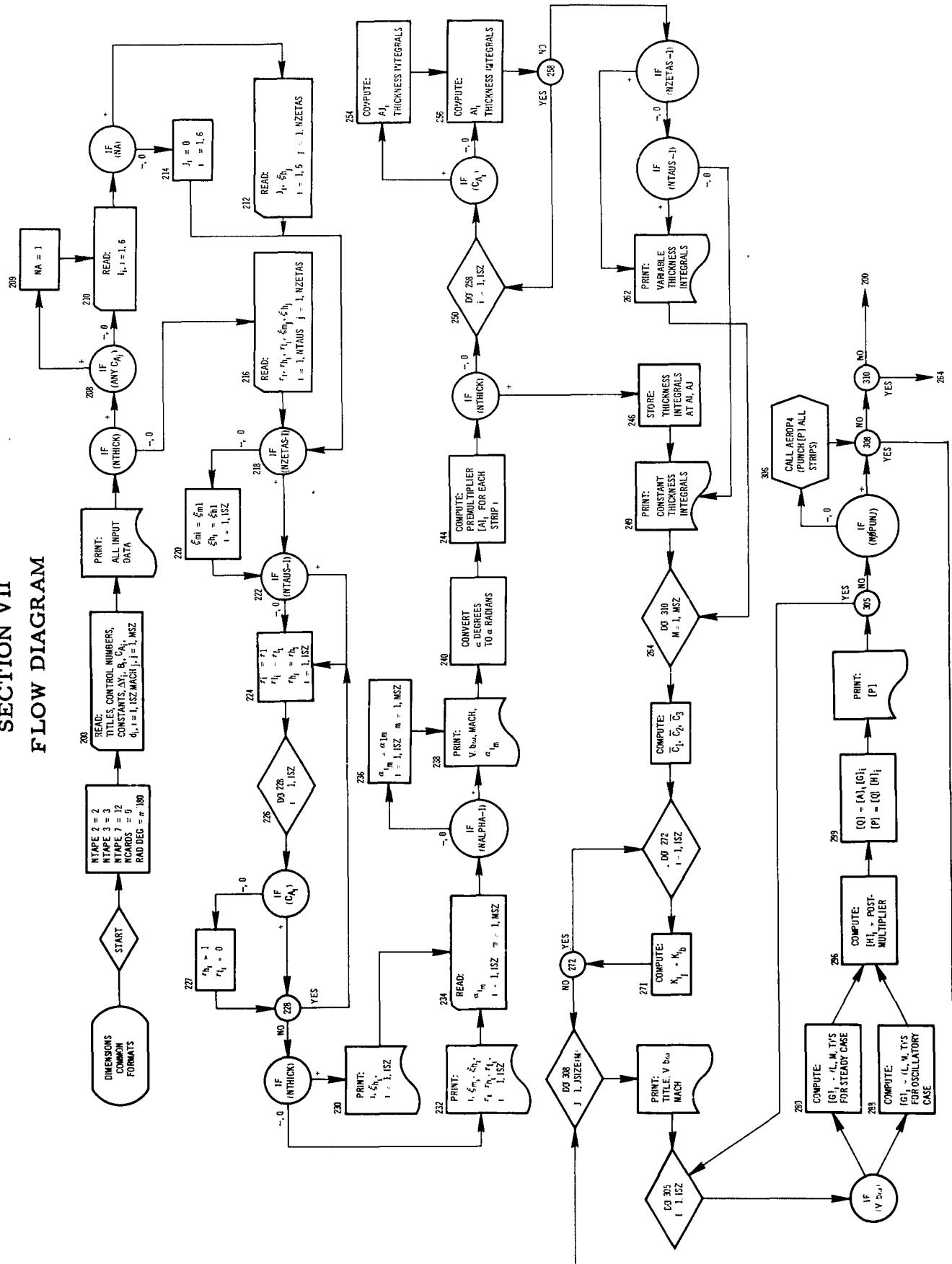
BINPU, column binary punch

All other subroutines are on library tapes

B. Generalized Tapes

Input, print, and punch tapes in this coding are defined as Units 2, 3, and 12, respectively; however, these may be altered by placing the desired units on symbolic cards HM110060, HM110061, and HM110062.

**SECTION VII  
FLOW DIAGRAM**



SECTION VIII  
SYMBOLIC LISTING

Some of the symbols used in the program are defined as follows:

<u>FORTRAN Symbols</u>	<u>Definition</u>
NTHRY	Option--theory used for $\bar{C}_1$ , $\bar{C}_2$
NTHICK	Option--thickness integrals given or computed
NALPHA	Option--a's constant or vary
NTAUS	Option-- $\tau$ 's constant or vary
NZETAS*	Option-- $\xi$ 's constant or vary
NØ PUNJ	Option--punching or no punching
ISZ	Number of strips
MSZ	Number of Mach numbers
J SIZE (M)	Number of reduced velocities for Mach number
JSZ	Number of reduced velocities for a Mach number
SEC LAM	$\sec \Lambda$
BR	$b_r$
S	s
CAP S	S
C BAR	$\bar{c}$

---

\*Please, no remarks about our Greek!

## SYMBOLIC LISTING (continued)

<u>FORTRAN Symbols</u>	<u>Definition</u>
C BAR 1	$\bar{C}_1$
C BAR 2	$\bar{C}_2$
RAD DEG	$\pi/180.0$ (program constant)
DELTA Y(I)	$\Delta y$ for strip i
B (I)	b for strip i
CA (I)	$c_a$ for strip i
D (I)	d for strip i
EMACH (M)	m'th Mach number
EKR (J, M)	$1/k_r = (V/b_r \omega)$ for reduced velocity j, for m'th Mach number
EI (N)	I series (thickness integrals)
EJ (N)	J series (thickness integrals)
AI (I, N)	I series for strip i
AJ (I, N)	J series for strip i
ZETA H (I)	$\xi_h$ for strip i
ZETA M (I)	$\xi_m$ for strip i
TAU (I)	$\tau$ for strip i
TAU H (I)	$\tau_h$ for strip i
TAU T (I)	$\tau_t$ for strip i
ALPHA (I, M)	$\alpha$ for strip i, for m'th Mach number
EK (I, N)	K series for strip i

## SYMBOLIC LISTING (continued)

<u>FORTRAN Symbols</u>	<u>Definition</u>
C $\varnothing$ NST (I)	$4(b/b_r)^2 \Delta y/s$ for strip i
A (I, N, K)	Premultiplying matrix in oscillatory coefficients matrix equation
G (N, K)	Real, oscillatory leading edge coefficient matrix
GI (N, K)	Imaginary matrix
H (N, K)	Postmultiplying matrix in oscillatory coefficients matrix equation
Q (N, K)	Working array
QI (N, K)	Working array
P (N, K)	AIC matrix, complex

The symbolic listing of the program is shown on the following pages.

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```

C 100F FOR 100    175
COMMON EKR, A1(25,3), TOTAL(Y(25)), TAUT(25),
      A1(25,6), CONST(25), C4(25), TAUH(25),
      A1(25,6), EK(25,6) , D(25), TAUT(25)
C (DIM. FOR (M),(J),(I),--MIXED) M=15,J=20,I=25
      DIMENSION EKR(20,15),ALPHA(25,15),E MACH(15),J SIZE(15)
C 100F FOR CONSTANT ARITHYS
      B1(BYTES) 61(3,3), 61(3,3), 61(3,3), 61(3,3)
      J1(16) ECRD
      J1(16) ECRD

COMMON EKR,ALPHA,E MACH,J SIZE,G,GI,H,P,PI,Q,QI,EJ
      1,EI,A,AJ,A1,EK,DELTA Y,B,CA,D,TAU H,TAU T,ZETA M
      2,VIA H,DEBYE

1 FORMAT F10(4)
2 FORMAT 16E12.8]
3 FORMAT 11H 33X, 35HAERODYNAMIC INFLUENCE COEFFICIENTS
      1 16HBY PISTON THEORY
      4 FORMAT 11H 33X, 16H INPUT DATA
      5 FORMAT 11H 54X, 10H INPUT DATA
      6 FORMAT 11H 54X, 13H MACH NUMBERS / 1147, 16H REDUCED FREQUEN
      7 14HCIES (TOTAL) / 1H0 44X, 15HSECANT LAMBDA = 1E16.8,
      8 /1H 55X, 4HBR = 1E16.8, / 1H 56X, 3HS = 1E16.8 / 1H
      9 36X = 1E16.8 / 1H 52X, 1HC BAR = 1E16.8 / 1H0
      5 13H, SHSTRIP 6X, 1H BETA Y 10 12X, 1HB(1) 19X,
      6 SHCRD(1) 16X, 4HBR(1) 17H 1E22, 21720.8, 1E19.8,
      7 1E21.8 ]
      6 FORMAT ( 1H0 51X, 18HSTRIP
      7 FORMAT ( 1H0 14X, 5HSTRIP 7X, 6H XI M 11X, 6H XI H 13X,
      1 1HAU 11X, SHTAU H 12X, SHTAU I 11X 11X, 2X,
      2 5E17.8 ]
      8 FORMAT ( 1H0 48X, PITCH NUMBER = 1E16.8 / ( 1H 53X, 8HJK(R) - 8HJK(R) ) 1E16.8 )
      1 1E16.8 ]
      9 FORMAT ( 1H 11X, 29HALPHA ZERO SERIES (DEGREES) = 6(1F8.2, 3X ) HM110038

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1      / (1H 40X, 6(1F8.2, 3X) )   )  HM110039
10 FORMAT (1H0 33X, 30HGIVEN THICKNESS INTEGRALS (CONSTANT) )  HM110040
1      16H FOR ALL STRIPS) )  HM110041
11 FORMAT (1H0 37X, 30HGIVEN COMPUTED THICKNESS INTEGRALS (CONSTANT) )  HM110042
1      16H FOR ALL STRIPS) )  HM110043
12 FORMAT (1H0 45X, 28HCOMPUTED THICKNESS INTEGRALS )  HM110044
13 FORMAT (1H0 5X, 5HSTRIP 7X, 4HJ(1) 12X, 4HJ(2) 12X, 4HJ(3) 12X,  HM110045
1      4HJ(4) 12X, 4HJ(5) 12X, 4HJ(6) // (119, 3X, 6E16.8) )  HM110046
14 FORMAT (1H0 5X, 5HSTRIP 7X, 4HJ(1) 12X, 4HJ(2) 12X, 4HJ(3) 12X,  HM110047
1      4HJ(4) 12X, 4HJ(5) 12X, 4HJ(6) // (119, 3X, 6E16.8) )  HM110048
15 FORMAT (1H0 5X, 5HSTRIP 7X, 4HJ(1) 12X, 4HJ(2) 12X, 4HJ(3) 12X,  HM110049
1      4HJ(4) 12X, 4HJ(5) 12X, 4HJ(6) // (119, 3X, 6E16.8) )  HM110049
16 FORMAT (1H0 53X, 11HSTEADY CASE // 1H 52X, 6HMACH = 1F 16.8,  HM110050
1      // 1H 50X, 17H1/K(R) = INFINITY // 1157, 7HSTRIPS )  HM110051
17 FORMAT (1H0 51X, 16HOSCILLATORY CASE // 1H 49X, 6HMACH = 1F16.8HM110052
1      // 1H 47X, 6H1/K(R) = 1E16.8 // 1157, 7HSTRIPS )  HM110053
18 FORMAT (1H0 43X, 3HCH(1) 1H, 8H) 4HFF = 112, 3H BY 112 )  HM110054
19 FORMAT (1H 30X, 3E18.8)  HM110055
20 FORMAT (1H 3X, 2E16.8, 1H) 2E16.8, 1H )  HM110056
21 FORMAT (1H 19X, 2E16.8, 1H) 2E16.8, 1H )  HM110057
22 FORMAT (1H 39X, 2E18.8)  HM110058
NTAPE7=12
NCARDS=0
RAD DEG=3.14159265 / 180.
READ INPUT FILE NIAPE2, NTAPE3, 11
CALL EDIN (NIAPE2, NTAPE3, 23)
READ INPUT TAPE NIAPE2, 1, ISZ, MSZ, NOPUNJ, (JSIZE(I), I=1, MSZ)  HM110065
READ INPUT TAPE NIAPE2, 1, ISZ, MSZ, NOPUNJ, (JSIZE(I), I=1, MSZ)  HM110066
READ INPUT TAPE NIAPE2, 2, SECLAIM, BR, S, CAPS, CBAR  HM110067
READ INPUT TAPE NIAPE2, 2, (DELTAY(I), I=1, ISZ)  HM110068
READ INPUT TAPE NIAPE2, 2, (DELTAY(I), I=1, ISZ)  HM110069
READ INPUT TAPE NIAPE2, 2, (CA(I), I=1, ISZ)  HM110070
READ INPUT TAPE NIAPE2, 2, (CA(I), I=1, ISZ)  HM110071
READ INPUT TAPE NIAPE2, 2, (CA(I), I=1, ISZ)  HM110072
READ INPUT TAPE NIAPE2, 2, (CA(I), I=1, ISZ)  HM110073
READ INPUT TAPE NIAPE2, 2, (EMACH(I), I=1, MSZ)  HM110074
READ INPUT TAPE NIAPE2, 2, (EMACH(I), I=1, MSZ)  HM110075
JDOC=0
)

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ALGORITHM FOR COMPUTING COEFFICIENTS BY PESTON THEORY.

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DO	202 I=1,MSZ	HM110077
202	JDOG=JDOG+JSIZE(I)	HM110078
	WRITE OUTPUT TAPE NTAPE3, 3	HM110079
IF	INT(NVY)=206,204	HM110080
204	WRITE OUTPUT TAPE NTAPE3, 4	HM110081
206	WRITE OUTPUT TAPE NTAPE3, 5, ISZ, MSZ, JDOG, SECLAM, BR, S, CAPS,	HM110082
1	CBAR, (I, DELTAY(I), B(I), CA(I), D(I), I=1,ISZ)	HM110083
2	IF (INT(NX)) 211,210,209	HM110084
208	NA=0	HM110085
208	IF (CA(I)) 210,210,209	HM110086
209	NA=1	HM110087
210	CONTINUE	HM110088
	READ INPUT TAPE NTAPE2, 2, (ZETAH(I),TAU(I))	HM110089
	IF (NA) 211,210,212	HM110090
212	READ INPUT TAPE NTAPE2, 2, (ZETAH(I),TAU(I))	HM110091
213	READ INPUT TAPE NTAPE2, 2, (ZETAM(I),TAU(I))	HM110092
214	GOTO 216	HM110093
214	GO 215 I=1,6	HM110094
215	END 1=0	HM110095
215	END 210	HM110096
216	READ INPUT TAPE NTAPE2, 2, (ZETAH(I),TAU(I))	HM110097
	READ INPUT TAPE NTAPE2, 2, (ZETAM(I),TAU(I))	HM110098
218	IF (NZETAS-1) 220,220,222	HM110099
220	DO 221 I=1,ISZ	HM110100
221	IF (ZETAH(I)=TAU(I))	HM110101
221	ZETAH(I)=TAU(I)	HM110102
221	END 221	HM110103
222	IF (INT(AUS-1) 224,224,226	HM110104
224	DO 225 I=1,ISZ	HM110105
	TAU(I)=TAU(I)	HM110106
225	IF (ZETAH(I)=TAU(I))	HM110107
225	ZETAH(I)=TAU(I)	HM110108
226	DO 228 I=1,ISZ	HM110109
	IF (CA(I)) 227,227,228	HM110110
227	ZETAH(I)=1.	HM110111
		HM110112
		HM110113
		HM110114

## AERODYNAMIC INFLUENCE COEFFICIENTS BY FINSTON THEORY.

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228 CONTINUE

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      IF ( NBLK ) 231-230
210 NR 116  OUTPUT TAPE NTAPE3, 6, 11, REFLAT(1,1)-ALPH3
      HN110115
      HN110116
      HN110117
      HN110118
      HN110119
      HN110120
      HN110121
      HN110122
      HN110123
      HN110124
      HN110125
      HN110126
      HN110127
      HN110128
      HN110129
      HN110130
      HN110131
      HN110132
      HN110133
      HN110134
      HN110135
      HN110136
      HN110137
      HN110138
      HN110139
      HN110140
      HN110141
      HN110142
      HN110143
      HN110144
      HN110145
      HN110146
      HN110147
      HN110148
      HN110149
      HN110150
      HN110151
      HN110152

```

230 READ INPUT TAPE NTAPE3, 7, 11, ZETAM(1), ZETAH(1), TAU(1),
 IF (NAPHA(1)) 236,241,238
 231-230
 232 WRITE OUTPUT TAPE NTAPE3, 7, 11, ZETAM(1), ZETAH(1), TAU(1),
 1, TAUH(1), TAUT(1), 1=1, ISZ
 233 READ INPUT TAPE NTAPE3, 7, 11, EKRA(1,1), EMACH(1,1), EKRB(1,1),
 IF (NAPHA(1)) 236,241,238
 234 GOTO 234
 235 WRITE OUTPUT TAPE NTAPE3, 7, 11, EKRA(1,1), EMACH(1,1), EKRB(1,1),
 1, EKRC(1,1), EMACB(1,1), EKRD(1,1), EMACD(1,1)
 236 DO 237 1=1,ISZ
 DO 237 M=1,MSZ
 237 ALPHA(1,M)=ALPHA(1,M)

 238 DO 240 1=1,ISZ
 111-JS2
 239 READ INPUT TAPE NTAPE2, 2, 1(EKR(J,1),J=1,JSZ)
 WRITE OUTPUT TAPE NTAPE3, 8, 1(EKR(J,1),J=1,JSZ)
 WRITE OUTPUT TAPE NTAPE3, 9, 1(ALPHA(J,1),J=1,ISZ)
 240-241
 241 DO 242 1=1,ISZ
 111-JS2
 242 READ INPUT TAPE NTAPE2, 2, 1(EKR(J,1),J=1,JSZ)
 WRITE OUTPUT TAPE NTAPE3, 8, 1(EKRC(J,1),J=1,JSZ)
 WRITE OUTPUT TAPE NTAPE3, 9, 1(ALPHA(J,1),J=1,ISZ)
 243-244
 244 DO 245 1=1,ISZ
 C1083711735 0.018(11)/(18)=1.0E-018 0.0000000000000000
 A1(1,1)=1.0E-018(11)/(18-0.00018) )
 A1(1,2)=1.0E-018(11)/(18-0.00018) )
 A1(1,3)=1.0E-018(11)/(18-0.00018) )
 A1(1,2,1)=B(1)/{2.0\*D(1) }
 A1(1,2,2)=--A(1,1,2)
 245-246
 246 IF ( E(1,1) ) 247-249
 247 A(1,1,1)=B(1)/(A(1,1,1)+C(1,1,1))
 A(1,1,2)=B(1)/(A(1,1,2)+C(1,1,2))
 A(1,1,3)=B(1)/(A(1,1,3)+C(1,1,3))
 A(1,1,1)=0.0
 A(1,1,2)=0.0
 A(1,1,3)=B(1)/CA(1)
 249-250
 250

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244 CONTINUE

```

IF( I .NE. 1 )      250, 250, 256
      NUMBER=1
      DO 248 1,1,151
        DO 248 N=1,6
          AJ(I,N)=EI(N)
          AJ(I,N)=0.
        IF( I .GE. 1 )      250, 250, 257
247   AJ(I,N)=JIN(I,NUMBER)
      NUMBER=1
248   CONTINUE
      WRITE OUTPUT TAPE NTAPE3, 10
249   WRITE OUTPUT TAPE NTAPE3, 13, NUMBER, (AJ(NUMBER,N), N=1,6)
      WRITE OUTPUT TAPE NTAPE3, 13, NUMBER, (ATENNUMBER(N,N), N=1,6)
      GO TO 254
250   NUMBER=1
      DO 258 I=1,ISZ
        T=TAU H(I)-TAU T(I)
        IF( I .GE. 1 )      252, 253, 254
252   DO 253 K=1,6
253   AJ(I,K)=0.0
      GO TO 256
254   NUMBER=I
      AJ(I,I)=0.5
      AJ(I,2)=0.25*(1.0-ZETA H(I))
      AJ(I,3)=-(1.0/6.0)*ZETA H(I)
      AJ(I,4)=0.25*T/I/(1.0-ZETA H(I) )
      AJ(I,5)=0.125*T*I*(1.0+ZETA H(I) )/((1.0-ZETA H(I) )*(1.0-ZETA H(I) ))
      AJ(I,6)=(1.0/12.0)*T*I*(1.0+ZETA H(I)*ZETA H(I) )
      1   /((1.0-ZETA H(I) )*(1.0-ZETA H(I) ))
256   CONTINUE
      TS=(TAU(I)-TAU H(I))*(TAU(I)-TAU H(I))
      AJ(I,1)=(TAU H(I)/2.0)+AJ(I,1)
      AJ(I,2)=-(TAU(I)/3.0)*ZETA H(I)+(TAU H(I)/6.0)

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1      *(12.0*ZETA H(I)+ZETA M(I))+AJ(I,2)          HM110191
      AI(I,3)=-(TAU(I)/12.0)*ZETA H(I)*(3.0*ZETA H(I)+2.0)  HM110192
1      ZETA H(I)=TAU(I)/12.0*ZETA H(I)+3.0*ZETA M(I)          HM110193
2      2.0*(1.4*ZETA H(I)+ZETA M(I))/TAU(I)+AJ(I,3)          HM110194
      AI(I,4)=TAU(I)/12.0*ZETA H(I)+3.0*ZETA M(I)          HM110195
1      *(4*ZETA H(I)-ZETA M(I))+AJ(I,4)          HM110196
      AI(I,5)=(TAU(I)*TAU(I)/12.0)+(1.0/12.0)*TS*(3.0
1      *ZETA H(I)+ZETA M(I))/((ZETA H(I))-ZETA M(I))+AJ(I,5)  HM110197
      AI(I,6)=TAU(I)/12.0*ZETA H(I)+3.0*ZETA M(I)          HM110198
1      0.5*(1.6*ZETA H(I)+ZETA M(I))+3.0*ZETA H(I)          HM110199
2      ZETA M(I)=ZETA H(I)/TAU(I)          HM110200
      2.0*CONTINUE          HM110201
      IF (NZETAS-1) 260,260,262          HM110202
      IF (INTAUS-1) 261,261,262          HM110203
      WRITE OUTPUT TAPE NTAPE3, 12          HM110204
      WRITE OUTPUT TAPE NTAPE3, 13, (I, (AJ(I,N),N=1,6),I=1,ISL)
      WRITE OUTPUT TAPE NTAPE3, 14, (I, (AJ(I,N),N=1,6),I=1,ISL)
      END 249          HM110205
      262 WRITE OUTPUT TAPE NTAPE3, 12          HM110206
      WRITE OUTPUT TAPE NTAPE3, 13, (I, (AJ(I,N),N=1,6),I=1,ISL)
      WRITE OUTPUT TAPE NTAPE3, 14, (I, (AJ(I,N),N=1,6),I=1,ISL)
      END 249          HM110207
      263 DO 310 N=1,NSH
      EMS=E MACH(M)*E MACH(M)          HM110208
      SEC$=SEC LAM*SEC LAM          HM110209
      IF (INTHRY) 266,266,268          HM110210
      266 CBAR1=L
      CBAR2=(1.4+1.0)/4.0
      END 310          HM110211
      268 CBAR1= EMACH(M) / SQR(EM(S-SEC$))
      CBAR2=(EMS*EMS*(1.4+1.0)-4.0*SEC$*(EM(S-SEC$)) 1 /(4.0*
1      (EMS-SEC$)*(EM(S-SEC$)))          HM110212
      270 CBAR3=(1.4+1.0)/4.0
      END 310          HM110213
      EK(I,J)=(1.0/E MACH(M))*(CBAR1+2.0*CBAR2+E MACH(M)*AI(I,1))
      1      +3.0*CBAR3*EMS*(AI(I,4)+ALPHA(I,M)*ALPHA(I,M))
      EK(I,2)=(1.0/E MACH(M))*(CBAR1+4.0*CBAR2+E MACH(M))          HM110221
      HM110222          HM110223
      HM110224          HM110225
      HM110226          HM110227
      HM110228

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1   *AI(1,2)+3.0*CBAR3*EMS*(2.0*AI(1,5)+ALPHA(1,M))*ALPHA(1,M))  HM110229
1   EK(1,3)=(4.0/(3.0*E MACH(M)))*(CBAR1+6.0*CBAR2+E MACH(M)*MACH(M)*AI(1,3))  HM110230
1   *CBAR3*EMS*(3.0*AI(1,6)+ALPHA(1,M)*ALPHA(1,M)))  HM110231
1
1 IF 1 (AJ(1,1))  272,274,273
271 EK(1,4)=(1./EMACH(M))*(CBAR1*(1.0-ZETAH(1,1))+2.*CBAR2
1   *EMACH(M)*AJ(1,1)+3.0*CBAR3*EMS*(AJ(1,4)+ALPHA(1,M))
2   *ALPHA(1,M)*(1.0-ZETA H(1,1)))
272 EXIT(1,0)
1   *CBAR3*EMS*(3.0*AI(1,6)+ALPHA(1,M)*ALPHA(1,M))
1   *CBAR3*EMS*(3.0*AI(1,6)+ALPHA(1,M)*ALPHA(1,M))
2   3.0*CBAR3*EMS*(3.0*AI(1,6)+ALPHA(1,M)*ALPHA(1,M))
273 EK(1,6)=(4.0/(3.0*E MACH(M)))*(CBAR1*(1.0-ZETA H(1,1)
1   *ZETA H(1,1)*ZETA H(1,1))+6.0*CBAR2*EMACH(M)*AJ(1,3)
2   +3.0*CBAR3*EMS*(3.0*AJ(1,6)+ALPHA(1,M)*ALPHA(1,M))
3   *CBAR3*EMS*(3.0*AJ(1,6)+ALPHA(1,M)*ALPHA(1,M))
274 END FILE
JSZ=JSIZE(M)
DO 308 J=1,JSZ
  WRITE OUTPUT TAPE NTAPE3, 15
  WRITE OUTPUT TAPE NTAPE3, 3
  IF 1 (NTAPE3) 275,275,274
274 WRITE OUTPUT TAPE NTAPE3, 4
275 IF 1 (EKR1J,M) 276,276,277
276 WRITE OUTPUT TAPE NTAPE3, 16, EMACH(M), ISZ
  GOTO 278
277 WRITE OUTPUT TAPE NTAPE3, 17, EMACH(M), ISZ
278 IF 1 (EKR1J,M) 280,280,288
280 G(1,1)=0.
  G(2,1)=0.0
  BB=BR*BR/1B(1)*B(1,1)
  G(1,2)=EK(1,1)*BB
  G(2,2)=EK(1,2)*BB
  IF 1 (AJ(1,1)) 282,282,287
282 G(1,3)=-EK(1,4)*BB
  G(2,3)=-EK(1,5)*BB
  G(3,1)=0.0
  HM110255
  HM110256
  HM110257
  HM110258
  HM110259
  HM110260
  HM110261
  HM110262
  HM110263
  HM110264
  HM110265
  HM110266

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G(3,2)=-EK(I,5)-2.0*EK(I,4)*ZETA H(I) )*BB		HM110267
G(3,3)=G(3,2)		HM110268
291 H(I) = 2916 1.000000		HM110269
292 2926 1.000000		HM110270
293 G(I,I) FIND=0.		HM110271
GOTO 292		HM110272
288 E1K=EKR(I,J,M)*BR/B(I)		HM110273
E1KS=E1K*E1K		HM110274
G(I,I)=0.0		HM110275
G(I,I)=EKR(I,I)*E1K		HM110276
G(I,I)=EKR(I,I)		HM110277
G(I,1,2)=-EK(I,2)*E1K		HM110278
G(2,1)=0.0		HM110279
G(I,2,1)=-EK(I,2)*E1K		HM110280
G(I,I)=EKR(I,I)*E1K		HM110281
G(I,I)=EKR(I,I)*E1K		HM110282
G(I,I)=EKR(I,I)*E1K		HM110283
IF ( G(I,I) ) 292 CONTINUE		HM110284
290 G(I,3)=-EK(I,4)*E1KS		HM110285
G(I,1,3)=-(EK(I,5)-2.0*EK(I,4)*ZETA H(I) )*E1K		HM110286
G(I,I)=EKR(I,I)*E1KS		HM110287
G(I,I)=EK(I,I)*E1KS		HM110288
G(I,I)=0		HM110289
G(I,3,1)=-(EK(I,5)-2.0*EK(I,4)*ZETA H(I) )*E1K		HM110290
G(I,3,2)=-(EK(I,5)-2.0*EK(I,4)*ZETA H(I) )*E1KS		HM110291
G(I,3,2)=-(EK(I,6)-2.0*EK(I,5)*ZETA H(I) )*E1K		HM110292
G(I,I)=EK(I,I)*E1KS		HM110293
G(I,I)=-(EK(I,I)*G(I,I)*E1KS+G(I,I)*ZETA H(I) )*E1KS		HM110294
1 *ZETA H(I) )*E1KS		HM110295
292 CONTINUE		HM110296
NU=2		HM110297
IF ( G(I,I) ) 293 CONTINUE		HM110298
294 NU=3		HM110299
295 DO 296 I=1,NU		HM110300
DO 296 I=1,NU		HM110301
296 H(I,IN)=A(I,IN,IT)		HM110302
H(3,1)=H(2,2)		HM110303
		HM110304

SUBROUTINE: TRIANGLE ROUTINE: ELEMENTS BY FINITE THEORY.			
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100	$H(3,2) = -(H(3,1) + H(3,3))$		
100	$C = 0.0$	$H(1,1) = 0.0$	HM110305
100	$Q(1,K,L) = 0.0$	$H(1,1,NU)$	HM110306
100	$Q(1,K,L) = 0.0$	$H(1,1,NU)$	HM110307
100	$Q(1,K,L) = 0.0$	$H(1,1,NU)$	HM110308
100	$Q(1,K,L) = 0.0$	$H(1,1,NU)$	HM110309
100	$Q(1,K,L) = 0.0$	$H(1,1,NU)$	HM110310
100	$Q(1,K,L) = 0.0$	$H(1,1,NU)$	HM110311
100	$Q(1,K,L) = 0.0$	$H(1,1,NU)$	HM110312
100	$Q(1,K,L) = 0.0$	$H(1,1,NU)$	HM110313
100	$Q(1,K,L) = 0.0$	$H(1,1,NU)$	HM110314
100	$Q(1,K,L) = 0.0$	$H(1,1,NU)$	HM110315
100	$Q(1,K,L) = 0.0$	$H(1,1,NU)$	HM110316
100	$DO 297 M=1,NU$		HM110317
297	$Q(1,K,L) = Q(1,K,L+1) + X_{K,L+1} - X_{K,L}$		HM110318
297	$Q(1,K,L) = Q(1,K,L+1) + X_{K,L+1} - X_{K,L}$		HM110319
297	$Q(1,K,L) = Q(1,K,L+1) + X_{K,L+1} - X_{K,L}$		HM110320
297	$Q(1,K,L) = Q(1,K,L+1) + X_{K,L+1} - X_{K,L}$		HM110321
298	$P(K,L,1) = P(K,M1) + Q(K,M1)*H(M1,LT)$		HM110322
298	$P(K,L+1,1) = P(K,L+1,1) + Q(K,M1)*H(M1,LT)$		HM110323
298	$P(K,L,1) = P(K,L,1) + CONST(L)$		HM110324
299	$P(K,L,1) = P(K,L,1) + CONST(L)$		HM110325
299	$P(K,L,1) = P(K,L,1) + CONST(L)$		HM110326
299	$P(K,L,1) = P(K,L,1) + CONST(L)$		HM110327
300	$CORR = 2.*S*CBAR/CAPS$		HM110328
300	$DO 301 K=1,NU$		HM110329
301	$DO 301 L=1,IN,2$		HM110330
301	$P(K,L,1) = P(K,L,1) + CORR$		HM110331
301	$P(K,L,1) = P(K,L,1) + CORR$		HM110332
301	$P(K,L,1) = P(K,L,1) + CORR$		HM110333
301	$P(K,L,1) = P(K,L,1) + CORR$		HM110334
305	$GOTO 305$		HM110335
312	$WRITE OUTPUT TAPE NTAPE3, 22, ((P(K,L,I),L=1,IN,2),K=1,NU)$		HM110336
305	$GOTO 305$		HM110337
305	$IF (IOPUNJ .EQ. 2) THEN$		HM110338
305	$WRITE OUTPUT TAPE NTAPE3, 20, ((P(K,L,I),L=1,IN,2),K=1,NU)$		HM110339
304	$WRITE OUTPUT TAPE NTAPE3, 21, ((P(K,L,I),L=1,IN),K=1,NU)$		HM110340
305	$CONTINUE$		HM110341
305	$IF ( NOPUNJ ) 308,306,308$		HM110342

AERODYNAMIC COEFFICIENTS BY PISTON THEORY 4/20/62

```
306 CALL AERO P4  (EKR(J,M),EMACH(M),P,ISZ,NCARDS,NTAPE3,NTAPE7,CA)  HM110343
      HM110344
      HM110345
      HM110346
      HM110347
      HM110348
      HM110349

310 CONTINUE
310 CONTINUE

      GOTO 200
END(1,0,0,0,0,0,0,0,1,0,0,0,0,0,0)
```

**MICROHYDRAULIC INFLUENCE COEFFICIENTS BY POSITION HISTORY**

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**STORAGE NOT USED BY PROGRAM**

DEC 061  
2112 04104

DEC 061  
30523 71377

**STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS**

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
41 30773 74375		41 30773 74375		41 30623 71677		ALPHA 327761 77005		A 31738 75161			
8 30648 73670		64 30623 71677		CNS 30773 73160		BEST 30673 73721					
D 30598 73606		EI 31354 75172		EJ 31360 75200		EKR 32561 77461					
EK 30823 74147		EMACH 31886 76216		GI 31847 76147		G 31856 76160					
H 31838 76136		JSIZE 31871 76177		PI 31379 75223		P 31829 76125					
91 31769 75211		9 31376 75222		TAUH 30573 73524		TAU 30573 73524					
INIT 30523 73473		ZETAH 30673 73677		ZETAY 30673 73677							

**STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENTS**

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
88 2311 04503		88 2370 04502		CAPS 23169 04500		CHTRI 23068 04500					
CHTR2 2311 04477		CBAB3 2366 04516		COA 2365 04475		CHTR 23065 04474					
CHTR 2310 04473		CBAB2 2362 04512		ERS 2361 04471		CHTR 23065 04470					
CHTR 2310 04473		ETES 2358 04466		IT 2357 04465		JDOG 2356 04464					
1 2359 04467		ISZ 2354 04462		M 2353 04461		MSZ 2352 04460					
JSZ 2355 04463		L 2350 04456		NCARDS 2349 04455		NOPUNJ 2348 04454					
NALPHA 2351 04457		NA 2350 04456		NTAPER 2345 04451		NTAUH 23456 04450					
NITRIP2 2317 04453		NITRIP3 2346 04452		NUMBER 2345 04455		NU 23450 04444					
NITRIP2 2317 04453		NITRIP3 2346 04452		NUMBER 2345 04455		NU 23450 04444					
NITRIP2 2317 04453		NITRIP3 2346 04452		NUMBER 2345 04455		NU 23450 04444					
NITRIP2 2317 04453		NITRIP3 2346 04452		NUMBER 2345 04455		NU 23450 04444					
S 2335 04437		T 2334 04436		SELAN 2337 04441		SECS 2336 04440					
				TS 2333 04435							

**SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS**

EFN	LOC	EFN	LOC	EFN	LOC	EFN	LOC	EFN	LOC
811	1 04370	812	2 04376	813	3 04374	814	4 04354		
815	5 04334	816	6 04214	817	7 04202	818	8 04151		
819	9 04133	81A	10 04112	81B	11 04072	81C	12 04052		
81D	13 04042	81E	14 04015	81F	15 03770	81G	16 03766		
81H	17 03741	81I	18 03714	81J	19 03703	81K	20 03677		

**811**      **21 01166**

**811**      **22 03657**

**ALPHABETIC LISTING OF SUBROUTINES BY PESTON DIRECTORY**

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**LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM**

	DEC	OCT	DEC	OCT	SQRT	DEC	OCT	(FILE)	DEC	OCT	
	00007	00007	RDLN	1 00001	00003	6 00006	6 00006	(TSH)	5 00005	5 00005	
ENTRY POINTS TO SUBROUTINES READ OUTPUT FROM LIBRARY											
AEROP4			RDLN		SQRT	(FILE)	(FPT)	(RTN)	(STH)	(TSH)	
6J	1959	03647	CJ60	2313	04411	CJ61	2314	04412	CJ100	2315	04413
CJ103	2316	04414	CJ104	2317	04415	CJ106	2318	04416	CJ107	2319	04417
CJ108	2320	04420	CJ108	2321	04421	CJ100	2322	04422	CJ10E	2323	04423
CJ152	2324	04424	CJ208	2325	04425	CJ20A	2326	04426	CJ20E	2327	04427
CJ196	2328	04430	CJ201	2329	04431	CJ20B	2330	04432	CJ20N	2331	04433
CJ200	2332	04434	CJ178	693	04435	CJ17D	503	04436	DJ162	1305	02431
CJ42L	615	01147	DJ430	1022	01176	DJ439	1221	02305	DJ455	1763	03343
CJ45G	1844	03464	DJ45R	1903	03557	DJ455	1924	03604	DJ53Q	1220	02304
DJ542	1304	02430	DJ555	1762	03342	DJ55G	1843	03463	DJ62L	614	01146
DJ640	1021	01175	DJ655	1923	03603	EJ3P	1107	02123	EJ4R	1648	03160

LOCATIONS OF NAMES IN LIBRARY VECTOR

	DEC	OCT	RDLN	1 00001	SQRT	DEC	OCT	(FILE)	DEC	OCT
	0 00000	0 00000	RDLN	3 00001	(TSH)	6 00006	6 00006	(TSH)	5 00002	5 00002
ENTRY POINTS TO SUBROUTINES READ OUTPUT FROM LIBRARY										
AEROP4			RDLN		SQRT	(FILE)	(FPT)	(RTN)	(STH)	(TSH)

EXPLANATION OF INTERNAL NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND BINARY LOCATIONS

	BN	LOC	BN	LOC	BN	LOC	BN	LOC	BN	LOC	
200	33	00026	202	74	00207	204	77	00224	206	78	00230
208	85	00302	209	88	00313	210	89	00315	212	96	00334
214	107	00361	215	108	00362	216	110	00367	218	120	00423
219	171	00177	221	173	00176	222	175	00170	224	175	00171
225	128	00113	226	129	00117	227	131	00165	228	133	00171
230	135	00417	232	141	00520	234	146	00550	236	154	00602
237	156	00616	238	157	00626	240	176	00770	242	184	01066
244	189	01125	246	191	01134	247	197	01161	248	199	01165
249	201	01202	250	214	01235	252	218	01257	253	219	01257

## AERODYNAMIC INFLUENCE COEFFICIENTS BY PISTON THEORY.

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254	221	01265	256	228	01364	258	236	01566	260	238	01577
261	239	01603	262	241	01610	264	256	01666	266	260	01705
268	263	01713	270	269	01751	271	271	02174	272	274	02306
275	280	01851	275	281	01962	276	282	02185	277	285	02492
282	287	02059	288	289	02435	292	295	02484	284	290	02517
286	302	02513	288	304	02523	290	315	02572	292	325	02722
294	326	02730	295	329	02732	296	331	02752	297	340	03036
298	349	03165	299	351	03201	300	355	03234	301	358	03272
306	316	03181	312	318	03162	302	316	03171	303	317	03136
314	315	03179	315	319	031543	308	319	031509	308	316	031605
319	317	03163									

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```
SUBROUTINE RDLN (NTAPE2, NTAPE3, I )
1 FORMAT(8OH
      1
      2 FORMAT(1H0)
      3 FORMAT(1H0 ) )
READ INPUT TAPE NTAPE2, 1
GOTO 4,5),1
      4 WRITE OUTPUT TAPE NTAPE3, 2
      5 WRITE OUTPUT TAPE NTAPE3, 3
      6 WRITE OUTPUT TAPE NTAPE3, 1
      RETURN
END(1,0,0,0,0,0,0,1,0,0,0,0,0,0)
```

## STORAGE NOT USED BY PROGRAM

DEC	INET	011
16	00114	37453 77461

## SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

IPN	LOC	011
011	00112	012 000013

## LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC	OCT	DEC	OCT
52	000060	0160	75 00113

## LOCATIONS OF NAMES IN CHARACTER VECTOR

DEC	OCT	DEC	OCT
{FIL}	3 00003	{RTN}	1 00001

## ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

{FIL}	{RTN}	{STH}	{TSH}
-------	-------	-------	-------

## EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IPN	LOC	IPN	LOC
•	•	5	10 00000	6 11 00052

```

SUBROUTINE AERO P4  (VBRW,XMACH,CH,ISTRIP,NSTART,NTAPE3,NTAPE7,
CA)
1  DIMENSION CH(3,6,70), NT2211 (CA(75))
1  FORMAT (1H12.3, 4H12.3, 1H14)          HM110369
2  FORMAT (1HO 40X, 24H PUNCHED CARDS NOS. HM11 114,       HM110370
10H THRU HM11 114 )                      HM110371
3  FORMAT (21A, 64X, 4HHM11 114 )           HM110372
                                         HM110373
4  READ 10044010160                         HM110374
10044010160
5  IS=NSTART
NITS=1
IF (VBRW) 4,4,5                           HM110375
4  NUTS=2
5  WRITE OUTPUT TAPE NUTS, 1, VBRW, XMACH, 1S
1,1,1,1,1
K=0
DO 7 I=1,ISTRIP
  IF (CA(I)) 7,7,6
7  IF (I=1)                                HM110376
    IF (I=2)                                HM110377
      IF (I=3)                                HM110378
        IF (I=4)                                HM110379
          IF (I=5)                                HM110380
            IF (I=6)                                HM110381
              IF (I=7)                                HM110382
                IF (I=8)                                HM110383
                  IF (I=9)                                HM110384
                    IF (I=10)                               HM110385
                      IF (I=11)                               HM110386
                        IF (I=12)                               HM110387
                          IF (I=13)                               HM110388
                            IF (I=14)                               HM110389
                              IF (I=15)                               HM110390
                                IF (I=16)                               HM110391
                                  IF (I=17)                               HM110392
                                    IF (I=18)                               HM110393
                                      IF (I=19)                               HM110394
                                        IF (I=20)                               HM110395
                                          IF (I=21)                               HM110396
                                            IF (I=22)                               HM110397
                                              IF (I=23)                               HM110398
                                                IF (I=24)                               HM110399
                                                  IF (CA(I)) 10,10,9
                                                    NUTS=6
9
10  NUTS=6
11  IF (M=1)                                HM110400
  DO 12 M=1,10
    DO 13 I=1,2
      DO 14 J=1,2
        DO 15 K=1,2
          IF (CA(I,J,K)) 16,17,18
16  M=M+1
17  IF (M=23) 13,11,11
18  M=M-22
11

```

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```
CALL BINPU (A,22,IORG,BCDZ,IS,NTAPE7)          HM110407
      IORG=IORG+22          HM110408
10    IF (M.EQ.0) GOTO 12          HM110409
     DO 11 I=1,22          HM110410
       A(I)=0.          HM110411
11    GOTO 18          HM110412
13    A(M)=CH(J,L,1)          HM110413
14    M=M+K-NURTS          HM110414
15    M=M+1
16    IF (M.EQ.16) GOTO 16          HM110415
     CALL BINPU (A,M,IORG,BCDZ,IS,NTAPE7)          HM110416
17    IS=IS+1          HM110417
     CALL BINPU (A,0,0,BCDZ,IS,NTAPE7)          HM110418
18    WRITE(BINPUT,15) IS, NURTS, IS          HM110419
     NURTS=IS+1          HM110420
     REWIND BINPUT          HM110421
19    END(1,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0)
```

## STORAGE NOT USED BY PROGRAM

	DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
1	314	00110	314	00110	314	00110	314	00110

## STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENTS

	DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
BLD	3112	001100	10110	3111	001100	10110	3110	001100
K	3018	001100	10110	3111	001100	10110	3110	001100
MUS	3015	001100	10110	3111	001100	10110	3110	001100

## SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EEH	EEH	EEH	EEH	EEH	EEH	EEH	EEH
011	1	000000	012	000000	013	000000	014	000000

## LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
J	295	001101	21	001101	31	001101	61	001101
K	294	001100	209	001100	302	001100	60	001100
L1488	293	001100	208	001100	301	001100	59	001100

## LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
B1014	2	000002	1010	000001	1010	000001	1010	000001

## ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

BINPUT (FILE) (STH)

## EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
4	12	00061		5	13	00063	6	19	00111
8	25	00137		9	30	00163	10	31	00165
11	36	00237		12	42	00261	13	54	00266
15	46	00311		16	49	00331	17	52	00347

## ROUTINE TO MOVE 100 CARDS ON TAPE. PAGE 1

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\*\*\*\*\* GATHERING SEQUENCE \*\*\*\*\*

\* TSX TSX BURSTS 4  
\* TSX LOC (NO. WORDS TO PUNCH)  
\* TSX LOC (CARD ORIGIN FOR 1ST CARD)  
\* TSX LCC (SEQ NO. OF 1ST CARD) \*\*\*\*\*

\* TSX LOC (SEQ ID FOR THIS BLOCK, 1ST AND 2ND CHARACTER BLANKS) \*\*\*\*\*

\* TSX LOC (INPUT TAPE NUMBER) \*\*\*\*\*

\* \*\*\*\*\* TO DECODE, NO LETTERS MAY BE OMITTED IN THIS IDENTIFICATION. \*\*\*\*\*

\* ITEMS MARKED (\*) MAY BE DELETED. BCD ID WILL BE UNCHANGED AND SEQ. NOS. WILL BE CONTINUOUS STARTING FROM 000. ALSO ORDER MAY BE SWITCHED.

\* THIS VERSION PUNCHES ONE LINE ONLY.

\*\*\*\*\* ENTRY BINPU \*\*\*\*\*

00006 ENTRY BINPU

\*\*\*\*\* SECTION \*\*\*\*\*

CCC00	743146623460	{IOS}
00001	746651623460	{WRS}
CC002	745123303460	(RCH)
00003	744534303460	{HIC}
00004	744534303460	{HIS}
00005	744534303460	{HIS}

\*\*\*\*\*

00006	0634 00 1	00142	BINPU SXA	X1.1
00007	0634 00 2	00143	SXA	X2.2
00010	-0500 60 5	00006	STA	6.6
00011	-2472 99 9	00931	STA	1.0
00012	0500 00 4	00001	STA	1.6
00013	0621 00 0	00062	STA	1.6
00014	-0500 60 4	00002	CAL*	2.4
00015	0602 00 0	77776	SLW	END

\*\*\*\*\*

HM110440  
HM110441  
HM110442  
HM110443  
HM110444  
HM110445  
HM110446  
HM110447  
HM110448  
HM110449

HM110450  
HM110451  
HM110452  
HM110453  
HM110454  
HM110455  
HM110456  
HM110457

WORD COUNT  
END=0 IF TRANSFER CARD

## INPUT ROUTINE TO WRITE EOF-SIN CARDS ON TAPE. FIBII

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0C016	0402	00 0	00325	SUB	D1		HM110458	
CC017	0622	00 0	00066	STD	LCCN		HM110459	
00018	0511	00 0	00061	SVA	COUNT,0		HM110460	
01021	0200	00 4	000103	ELA*	3,4	SET UP CONTROL MODE	HM110461	
01022	0711	00 0	00022	ARE	18		HM110462	
0C023	-0120	00 0	00025	TMI	*+2	ADD RELATIVE BIT	HM110463	
0C024	-0501	00 0	00266	ORA	REL	7-9, WORD COUNT=22	HM110464	
00025	-0501	00 0	00334	ORA	IMAGE		HM110465	
00026	0502	00 0	07749	SVA	CIMAGE	CONTINUE WORD TEST/IMAGE	HM110466	
						*****	HM110467	
						TEST FOR FOURTH AND OR FIFTH ARGUMENTS.	HM110468	
						DETERMINE WHETHER ARGUMENT REFERS TO ID OR SEQ NUMBER	HM110469	
						AND SET CELLS FROM CALLING SEQUENCE.	HM110470	
						*****	HM110471	
00027	1115	00 2	000002	AXT	2,2	SET BLSEQ TO ITS NORMAL STATE	HM110472	
00030	-05621	00 0	000302	STL	BLSEQ	TEST FOR 4TH, 5TH ARGS	HM110473	
00031	-05309	00 4	000006	G4	GAL	*****	HM110474	
0C032	-0320	00 0	00265	ANA	MSKPDT		HM110475	
0C033	0322	00 0	00307	ERA	MSKTSX		HM110476	
00034	-0100	00 0	00054	TNZ	G2	NO MORE TSXES	HM110477	
00035	0500	00 4	000004	ELA*	4,4		HM110478	
00036	03109	00 0	000262	LAS	BLTB		HM110479	
00037	00249	00 0	000051	TRA	G3	BIG, THIS IS 10	HM110480	
00040	0600	00 0	00302	STZ	BLSEQ	EQUAL, FLAG BLANK SEQ. NO.	HM110481	
00041	-0100	00 0	00043	TNZ	*+2	IS SEQ NO NON-ZERO.	HM110482	
1	00042	-0754	00 0	00000	PXD	NO	HM110483	
	00033	-01139	00 0	000000	XCI	SMALL, THIS IS SEQ NO.	HM110484	
	00034	05636	00 4	00006	SVA	***2,4	HM110485	
	00035	00114	00 4	00112	TXI	CONVERT SEQ NO TO 860	HM110486	
	CC046	0774	00 4	00000	AXT	***4	HM110487	
	00047	0602	00 0	00267	SLW	SAVE	HM110488	
	00050	1 77777	4	00053	TXI	SEBID	HM110489	
	00051	0601	00 0	00005	SIG	MOVE TO NEXT ARGUMENT	HM110490	
	00052	1 77777	4	00013	TXI	AT MOST 2 EXTRA ARGS.	HM110491	
	00053	2 00001	2	00031	ES3	AT MOST 2 EXTRA ARGS.	HM110492	
	00054	0634	00 4	00144	G2	X4*4	HM110493	
	00055	-0520	00 0	07776	N2T	END	HM110494	
	0C056	0020	00 0	00152	TRA	TRCD	MUST BE A TRANSFER CARD	HM110495

## ROUTINE TO WRITE COIN CARDS ON TAPE. FILE#

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```

***** BUILD THE CARD IMAGE. ***** HM110496
***** COUNT ***** HM110497
***** LDQ ***** HM110498
***** STQ ***** HM110499
***** CLNGTHTP ***** HM110500
***** AXT ***** HM110501
***** **,4 ***** HM110502
***** NEVE ARRAY INIT CORE. ***** HM110503
***** CHNGTHTP ***** HM110504
***** AXT ***** HM110505
***** CHNGTHTP ***** HM110506
***** OUT,4,* ***** HM110507
***** TXH ***** HM110508
***** ARRAY,2,1 ***** HM110509
***** TIX ***** HM110510
***** SIA ***** HM110511
***** COUNT,4 ***** HM110512
***** SET COUNT FOR NEXT COIN. ***** HM110513
***** ADD IN CONTROL WORD. ***** HM110514
***** PUS CHEEKSUM IN IMAGE. ***** HM110515
***** EDIT THE IDENTIFICATION FIELD. ***** HM110516
***** CAL ***** HM110517
***** LDQ ***** HM110518
***** L11) ***** HM110519
***** LGR ***** HM110520
***** CAL ***** HM110521
***** BCDID ***** HM110522
***** LGL ***** HM110523
***** S19 ***** HM110524
***** LDH10 ***** HM110525
***** AXL ***** HM110526
***** SV1,1 ***** HM110527
***** AXT ***** HM110528
***** 4,2 ***** HM110529
***** AXT ***** HM110530
***** 2,4 ***** HM110531
***** AXT ***** HM110532
***** 3,1,1 ***** HM110533
***** AXT ***** HM110534
***** 12 ***** HM110535
***** ALS ***** HM110536
***** TRA ***** HM110537
***** *-3 ***** HM110538

```

## FINISH ROUTINE TO WRITE COL BIN CARDS ON TAPE - FINISH

```

00113 0602 00 2 77734          SLW      LAST+4,2          COL BIN AT LAST TO LAST+3
00114 1 77777 2 00115          TAXI    *+1,2,-1
00115 2 000001 4 000105          FIX      *RC*4,1
00116 00000 00 0 000126          L00Q     FINISH M/SAVED ((H9))-
00117 3 00000 2 00106          FIX      *RC*0
00120 0774 00 1 00000          SV1      AXT   **,1

```

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```

***** THE ENTIRE CARD IMAGE IS BUILT, WITH THE BODY
***** OF CARDS THRU CHASE23, AND ID AT ((S)) THRU LAST+3.
***** NOW **** WRITE THE CARD ON TAPE. *****

00121 0761 00 0 00000          WRITE NOP          $((H9))  START ISH ((H9) FOR TAPE 14.
00122 -0500 00 0 00331          WRITE1 CAL        14D
00123 00 0 00 0 00000          EARL    ((H9))
00124 00 0 00 0 00000          RELE    ((H9))
00125 -0115 60 4 00113          ATE     DUNCHAD
00126 0522 60 0 00002          XEC*    $((RC))
00127 0754 00 4 00000          PXA     0,4
00130 0621 60 0 00003          STA*    $((WTG))
00131 0174 00 5 00004          TSH     S1HEDTA
00132 -01000 00 0 00267          GAL     SERRIO
00133 0000 00 0 00324          ADD     L11
00134 0114 06 0 00215          CVR     TB1,0,6
00135 0602 00 0 00267          SLW     SEQNO
00136 0520 00 0 77776          ZET     END      TEST IF LAST CARD.
00137 0070 00 0 00116          TIA     SWTCH
00138 -0500 00 0 00111          C1     BYTES
00139 0071 00 0 00005          SLW     311FSY
00140 -0500 00 0 00005          SLW     311FSY
00141 0774 00 1 00000          X1      AXT   **,1
00142 0774 00 2 00000          X2      AXT   **,2
00143 0774 00 4 00000          X4      AXT   **,4
00144 0774 00 1 00000          TIA     5,6
00145 0070 00 0 00005          SLW

```

\*\*\*\*\* ALL DONE. EXIT  
NOT THE LAST CARD.\*\*\*\*\*

\*\*\*\*\* INCREMENT CARD COUNT.\*\*\*\*\*

\*\*\*\*\* TEST IF LAST CARD.\*\*\*\*\*

\*\*\*\*\* UPDATE THE CARD ORIGIN.\*\*\*\*\*

```

00146 -0500 00 0 77740          SWTCH
00147 0361 00 0 00333          CAL
00150 0602 00 0 77740          ACL
                                         SLW
                                         CIMAGE
                                         A22
                                         CIMAGE

```

## SUBROUTINE TO WRITE ON TAPE. FIG1

PAGE 5

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00151 0020 00 0 00057 TRA NEXT

```

      00152 0114 00 2 00017    TRD   AVT   7372
      00153 0000 00 2 71119    STZ   CIMAGE2112
      00154 2 00001 2 00153    TIX   *-1,2,1
      00155 0500 00 0 00322    CLA   2WC
      00156 0622 00 0 77740    STD   CIMAGE
      00157 0010 00 0 000073    TRA   EDI
      00158 0000 00 0 000073    STZ   CIMAGE2112
      00159 0000 00 0 000073    STZ   CIMAGE2112
      00160 0600 00 0 77776    OUT
      00161 -2 00001 2 00070    IN,2,1
      00162 0002 00 0 77777    TNX
      00163 0114 00 2 00000    SEL   EDI
      00164 0102 00 0 77749    STD   CIMAGE
      00165 0622 00 0 77740    COMMON
      00166 -0500 00 0 77777    CAL   IN,2,0
      00167 -3 00000 2 00070    TXL   CIMAGE2112
      00168 0000 00 2 77740    SEL   CIMAGE2112
      00169 1 77777 2 00073    TRA   *-2,2,1
      00170 0000 00 0 000073    STZ   CIMAGE2112
      00171 0000 00 0 000073    STZ   CIMAGE2112
      00172 -0114 00 0 00000    EDI
      00173 -0114 00 0 00000    EDI
      00174 0020 00 0 00211    TRA   COSEQX
      00175 0765 00 0 00022    LRS   10
      00176 0221 00 0 00332    DVP   TEN
      00177 0001 00 0 00000    STD   COMMON
      00178 0011 00 0 00000    PRO   FEN
      00179 0011 00 0 00000    DVP   FEN
      00201 0767 00 0 00006    ALS   6
      CC202 0767 00 0 00006    ORS   COMMON
      00203 -0602 00 0 77777    ORS
      00204 -0754 00 0 00000    PXD
      1

```

\*\*\*\*\* THIS ROUTINE CONVERTS A BINARY INTEGER TO BCD. (4 DIGITS DECIMAL) \*\*\*\*\*

\*\*\*\*\* THIS ROUTINE TESTS IF BLANKS DESTINED. \*\*\*\*\*

\*\*\*\*\* THIS ROUTINE RIGHT ADJUST BIN INTEGER \*\*\*\*\*

\*\*\*\*\* HM110595 \*\*\*\*\*

\*\*\*\*\* HM110596 \*\*\*\*\*

\*\*\*\*\* HM110597 \*\*\*\*\*

\*\*\*\*\* HM110598 \*\*\*\*\*

\*\*\*\*\* HM110599 \*\*\*\*\*

\*\*\*\*\* HM110600 \*\*\*\*\*

\*\*\*\*\* HM110601 \*\*\*\*\*

\*\*\*\*\* HM110602 \*\*\*\*\*

\*\*\*\*\* HM110603 \*\*\*\*\*

\*\*\*\*\* HM110604 \*\*\*\*\*

\*\*\*\*\* HM110605 \*\*\*\*\*

\*\*\*\*\* HM110606 \*\*\*\*\*

\*\*\*\*\* HM110607 \*\*\*\*\*

\*\*\*\*\* HM110608 \*\*\*\*\*

\*\*\*\*\* HM110609 \*\*\*\*\*

## INPUT ROUTINE TO INSTEAD OF CARDS ON TAPES, EIGHT

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	TEN	DVP	RIGH	BLANK	BLANK	BLANK	BLANK	BLANK	BLANK
	ALS	ALS	ALN	ALN	ALN	ALN	ALN	ALN	ALN
00205	0221 00 0 00332								
00206	0767 00 0 00014								
00207	0301 00 0 00000								
00210	00020 00 0 00000								
00211	-9289 00 0 000100								
00212	0020 00 4 00001								

\* TABLE FOR BCD ADDITION OF 1 TO C(ACC)

	TBL	TBL	TBL	TBL	TBL	TBL	TBL	TBL	TBL
	0	1	2	3	4	5	6	7	8
00215	0000 00 0 00014								
00216	0100 00 0 00215								
00217	0200 00 0 00215								
00220	0300 00 0 00215	FAD	TBL						
00221	0400 00 0 00215	ADD	TBL						
00222	0500 00 0 00215	CLA	TBL						
00223	0600 00 0 00215	STZ	TBL						
00224	0700 00 0 00215	CPI	TBL						
10	00125 1 000000 0 00015	TBL	TBL						
CO226	1 10000 0 00215	TXI	TBL	0,4096	9				
CO227	0000 00 0 00216	MTR	TB		0 WITH CARRY				

\* TABLES FOR BCD-COL. BIN. CONVERSION

\* HOLES ARE FILLED IN WITH CONSTANTS

\* HOLE IS LOCATED IN LINE 40110, 40120

	TBL	TBL	TBL	TBL	TBL	TBL	TBL	TBL	TBL
	0	1	2	3	4	5	6	7	8
CC230	0000000000000000								
CC231	1000000000000000								
00232	+0000000000200								
00233	+0000000000100								
CC234	+000000000040								
CC235	+0000000000000000								
00236	+0000000000000010								
00237	+0000000000000000								

\* TABLES FOR BCD-COL. BIN. CONVERSION

\* HOLES ARE FILLED IN WITH CONSTANTS

\* HOLE IS LOCATED IN LINE 40110, 40120

	TBL	TBL	TBL	TBL	TBL	TBL	TBL	TBL	TBL
	0	1	2	3	4	5	6	7	8
CC240	+0000000000002								
CC241	+00000000001								
0C242	-37777770000								

	TBL	TBL	TBL	TBL	TBL	TBL	TBL	TBL	TBL
	0	1	2	3	4	5	6	7	8
MSK2CH OCT	77777770000,102,42								

	TBL	TBL	TBL	TBL	TBL	TBL	TBL	TBL	TBL
	0	1	2	3	4	5	6	7	8
HM110638	HM110637								

## BASIC ROUTINE TO WRITE OUT DATA CARDS ON TAPE. FILE

4/20/62

PAGE 6

00205	0221	00 0	00332	DVP	TEN	HM110610
00206	0767	00 0	00014	ALS	12	HM110611
00207	0000	00 0	00017	TRN	FOLLOW	HM110612
00208	0000	00 0	00017	TRN	174	HM110613
00209	0000	00 0	000011	TRN	BLANK	HM110614
00210	0000	00 0	000000	CUSTOM CAL	BLANK	HM110615
00211	-0100	00 0	000000	TRA	1,4	HM110616
00212	0020	00 4	00001	TRA	*****	HM110617

00213	000000	0	11110	PUNCHED	TYPEP	CHANGE 0,24	HM110618
00214	000000	0	11110	1000	TEST	0,3	HM110619

## \* TABLE FOR BCD ADDITION OF 1 TO C(ACC)

00215	0000	00 0	00015	TBI	AIR	TBI	0	HM110620
00216	0100	00 0	00015	TR	SIZE	TBI	1	HM110621
00217	0100	00 0	00015	TR	IPY	TBI	2	HM110622
00220	0300	00 0	00215	FAD	TBI	TBI	3	HM110623
00221	0400	00 0	00215	ADD	TBI	TBI	4	HM110624
00222	0500	00 0	00215	CLA	TBI	TBI	5	HM110625
00223	0600	00 0	00215	STI	TBI	TBI	6	HM110626
00224	0700	00 0	00215	DPY	TBI	TBI	7	HM110627
00225	1	00000	0	00215	TXI	TBI	0	HM110628
00226	1	10000	0	00215	TXI	TBI,0,4096	9	HM110629
00227	0000	00 0	00216	MTR	TB	0 WITH CARRY	HM110630	

## \* TABLES FOR BCD-COL. BIN. CONVERSION

00230	0000000000000000	0000000000000000	0000000000000000	Holes are filled in with constants	HM110631
00231	0000000000000000	0000000000000000	0000000000000000	HM110632	

00232	+0000000CC0200	0000000000000000	0000000000000000	HM110633
00233	+000000000100	0000000000000000	0000000000000000	HM110634
00234	+000000000400	0000000000000000	0000000000000000	HM110635
00235	1000000000000000	0000000000000000	0000000000000000	HM110636
00236	0000000000000000	0000000000000000	0000000000000000	HM110637

00240	+0000000C00002	0000000000000000	0000000000000000	MSK2CH OCT	777777770000,102,42	HM110638
00241	+0000000000101	0000000000000000	0000000000000000			
00242	-377777770000	0000000000000000	0000000000000000			

## BIN20 BROUTIN TO INITIE COL. BIN FAMILIES ON TABLE: #IB11

					PAGE 7
					4/20/62
00243	+00000CCC001C2				
00244	+000CC0CCC00042				
00245	*0000000000000000	10173	BLT	01010	
00246	*0000000000000000				HMI10649
00247	*0000000000000000				
00250	+000000004000	OCT		4000,4400,4200,4100,4040,4020,4010,4004,4002,4001	
00251	+000000004400				HMI10640
00252	+000000004200				
00253	*0000000000000000				
00254	*0000000000000000				
00255	*0000000000000000				
00256	+000000004010				
00257	+000000004004				
CC260	+000000004C02				
H261	-10173				
H262	10173				
01263	*0101000000000002	00118	REC1	118	
01264	+000000004C42	001		3107,41092	HMI10641
0C265	-3 77777 7 00000	MSKPDT	TXL	0,7,-1	
A	0C266 0400 00 0 00000	REL	ADD		HMI10642
001763	*0000000000000000	SEQNO	REC1		
001770	*0000000000000000	REC			
001771	*0000000000000000				
C0272	+000000002200			4000,2400,22000,21000,2040,2010,2004,2002,2001	
00273	+000000002100				
00274	+000000002040				
00275	*0000000000000000				
00276	*0000000000000000				
00277	*0000000000000000				
00300	+000000002C02				
00301	+0C0000002C01				
00302	0 00000 0 00000	BLSEQ			
00303	*0010000000000002	001		2107,31062	HMI10647
00304	*0010000000000002				
00305	*0010000000000000	BEDID	REC1		HMI10648
00306	606060606060	BLANK	BC1	1,	
00307	0074 00 0 0C000	MSKTSX	TSX	'0	HMI10649
00310	+00000000000000	OCT		0,1400,1200,1100,1040,1020,1010,1004,1002,1001	HMI10650
					HMI10651
					HMI10652

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00311	+0000000001400
00312	+0000000001200
00313	+0000000001100
00314	+0000000001000
00315	+0000000000900
00316	+0000000001010
00317	+0000000001004
00320	+0000000001002
00321	+0000000000901
00322	+0000000000801
00323	+0000000000702
00324	+0000000001042
00325	0 00001 0 000
00326	0 00000 0 000
00327	0 00000 0 000
00328	0 00000 0 000
00329	0 00000 0 000
00330	0 00000 0 000
00331	0 00000 0 000
00332	+0000000000012
00333	000 00 0000000
00334	+00052600000

ROUTINE TO WRITE COL BIN CARDS ON TAPE. FILE

POST PROCESSOR ASSEMBLY DATA

335 IS THE FIRST LOCATION NOT USED BY THIS PROGRAM

LOCNES TO DEFINED SYMBOLS

330	5A	
325	D1	16
54	G2	34
51	G3	37
34	G4	53
33	G5	50,
70	IN	161,
216	18	167
142	X1	6
143	X2	7
144	X3	54
131	X5	11,
333	A22	147
105	ABC	115,
77776	END	15,
168	BET	55,
266	BLT	136,
125	BLT	160
230	TAB	107
215	TBI	134,
332	TEN	215,
322	INC	201,
322	DEC	205
73	BLT	137
77730	LAST	113,
66	LOCN	214
327	L(1)	17,
327	L(1)	74,
327	NEST	133
152	NEST	131
62	ANALY	16
305	BCDID	51,
6	BINPU	76
306	BLANK	0
302	BLNK	211
302	BLNK	40,
302	BLNK	173

INPUT FROM THE 10 MILEAGE BIN CARDS ON TABLE EIGHT  
POST PROCESSOR ASSEMBLY DATA

131	BPTES	140				
132	C0SEQ	45				
133	COMMON	20,	70			
134	DATA					
326	10LCD	100,	116			
334	IMAGE	25				
267	SEQNO	47,	73,	132,	135	
135	SPLITR	137				
172	SWTCH					
0	TEMP	12,				
2	(RCH)	126				
5	(TES)	141				
4	(WER)	131				
1	EMED	128				
3	EMIT	130				
1170	ERASE	20,	63,	91,	123,	146,
77777	COMMON	162,	166,	177,	203,	335
211	C0SEQX	174				
242	MSK2CH					
365	MSK2CH	32				
107	MSK2CH	33				
213	MSK2CH	123				
122	WRITE1					

END OF INPUT ASSEMBLY.

\* DATA

ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY,

MACHINE Tape	TOTAL WRITES	TOTAL READS	NOISE RECORDS		TOTAL REDUNDANCIES		POSITIONING ERRORS	
			WRITING	READING	WRITING	READING	WRITING	READING
A 1	0	710	0	0	0	0	0	0
A 2	591	674	0	0	0	0	0	0
A 3	125	63	0	0	0	0	0	0
A 4	450	535	0	0	0	0	0	0
A 2	0	677	0	0	0	0	0	0
A 3	579	3	0	0	0	0	0	0
A 4	139	102	0	0	0	0	0	0
TOTALS								

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prepared by W. P. Rodden, E. F. Farkas, H. A. Malcolm and A. M. Kliszewski. 15 August 1962. [90] p. incl. illus.

(Report TDR-169(3230-11)TN-2;SSD-TDR-62-75)  
(Contract AF 04(695)-169) Unclassified report

In this report we present a method for calculating the aerodynamic influence coefficients (AICs) based on third-order piston theory with an optional correction to agree with Van Dyke's quasi-steady second-order theory. The AICs are computed assuming the airfoil to have a rigid chord with or without a (rigid chord) control surface. The influence coefficients relate the surface deflections to the aerodynamic forces through the following definitions in the oscillatory case,  $|F| = \rho w^2 b_r s [C_h] |h|$  and in the steady state,  $|F| = \rho w^2 b_r s [C_h] |h|$  (over)

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case,  $|F_s| = (1/2)\rho V^2(S/\bar{c}) [C_{hs}] |h|$ . The piston theory is limited to high Mach number (or high reduced frequency), but Van Dyke's quasi-steady correction extends the validity to some lower supersonic Mach number at low reduced frequency. The Aerospace IBM 7090 Computer Program Number HM11 provides the AICs from this theory in both a printed and an optional punched-card output format. The program capacity is 25 surface strips, 15 Mach numbers, and 20 reduced velocities for each Mach number.

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foil to have a rigid chord with or without a (rigid  
chord) control surface. The influence coefficients  
relate the surface deflections to the aerodynamic  
forces through the following definitions in the oscil-  
latory case,  $|F| = \rho \omega^2 b_r^2 s [C_h] |h|$  and in the steady  
(over)

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chord) control surface. The influence coefficients  
relate the surface deflections to the aerodynamic  
forces through the following definitions in the oscil-  
latory case,  $|F| = \rho \omega^2 b_r^2 s [C_h] |h|$  and in the steady  
(over)

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case,  $|F_s| = (1/2)\rho V^2(S/\bar{c}) [C_{hs}] |h|$ . The piston theory is limited to high Mach number (or high reduced frequency), but Van Dyke's quasi-steady correction extends the validity to some lower supersonic Mach number at low reduced frequency. The Aerospace IBM 7090 Computer Program Number HM11 provides the AICs from this theory in both a printed and an optional punched-card output format. The program capacity is 25 surface strips, 15 Mach numbers, and 20 reduced velocities for each Mach number.

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